Final
Environmental Assessment
Mather Point Orientation/Transit Center and Transit System

July 1997

GRAND CANYON

National Park · Arizona

United States Department of the Interior · National Park Service

SUMMARY

The *Draft Environmental Assessment, Mather Point Orientation/Transit Center and Transit System*, published in March 1997, provided the National Park Service's proposal to construct the Mather Point orientation/transit center and transit system with its southern terminus at a gateway facility in Tusayan, Arizona, as described in the approved 1995 *General Management Plan/Final Environmental Impact Statement, Grand Canyon National Park*. Alternatives for this project were formulated to implement a portion of the approved 1995 plan and were developed in coordination with the work of the U.S. Forest Service and its partners on the 1997 *Draft Environmental Impact Statement for Tusayan Growth*. It is intended that the transit system outlined in this *Final Environmental Assessment* and the transportation staging area considered in the *Draft Environmental Impact Statement for Tusayan Growth* would be coordinated.

The *Draft Environmental Assessment* analyzed the impacts of taking no action and three action alternatives. Common to all action alternatives is the development of the Mather Point orientation/transit center. The three action alternatives differ in the number of private automobiles accommodated at the Mather Point facility and the mode of transportation between Tusayan and Mather and within the South Rim; transportation vehicles include buses and light rail. The action alternatives foster and promote an enhanced visitor experience and offer differing transportation methods to achieve this goal.

The *Draft Environmental Assessment* was on formal public review for 30 days, from March 17, 1997, to April 16, 1997, and a total of 59 letters of comment were received from governmental agencies, Indian Tribes, private businesses, and the public. The original letters are on file with the Grand Canyon I-Team Manager, 3100 North Fort Valley Road, Building 12, Flagstaff, Arizona 86001-8300, and copies may be requested under the Freedom of Information Act.

Commentors generally expressed a preference for light rail service and for no tour bus parking at Mather Point, and some commentors provided information to support their preference. Many supporters of light rail also expressed a preference of fuel sources other than diesel.

This *Final Environmental Assessment* includes the National Park Service's proposed action to implement the Mather Point orientation/transit center and transit system. Development of the proposed action was supported with public comment of the *Draft Environmental Assessment* and the necessity to address pertinent visitor needs and management issues, and to conserve resource values.

The full text of the draft document has not been reprinted here. This final document contains information pertinent to the proposed action and the environmental consequences of the proposed action, and should be used as a companion document with the draft. This approach is in accordance with the *Code of Federal Regulations*, title 40, part 1503.4, the "Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act." This

format also complies with the overall federal effort to decrease paperwork, to streamline the planning process, and to reduce printing costs.

The 30-day public review period for this *Final Environmental Assessment* ends on August 15, 1997. All comments must be received by that time and should be addressed to:

Grand Canyon I-Team Manager
3100 North Fort Valley Road
Building 12
Flagstaff, Arizona 86001-8300

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INTRODUCTION

The *Draft Environmental Assessment for the Mather Point Orientation/Transit Center and Transit System* (hereafter cited as draft assessment) was developed to implement a portion of the approved 1995 *General Management Plan* for Grand Canyon National Park, which called for construction of a staging facility near Mather Point to function in orienting visitors to sites and experiences on the South Rim. The plan envisioned the Mather Point facility to be linked to a transportation staging area just north of Tusayan (see the "Relationship to Previous, Current, and Future Planning Efforts" section in the draft assessment). According to the general management plan, parking for approximately 1,225 private automobiles and 60 tour buses would be provided at the Mather Point center, although most South Rim visitors would start their trip in Tusayan at the Tusayan gateway facility by boarding a private tour bus or a park transit bus and arrive at the Mather Point orientation and transit center. Upon arriving at the center, visitors would board shuttle buses to reach various destinations on the South Rim.

In addition to other elements, the draft assessment analyzed the environmental consequences of (1) providing visitor parking at the Mather Point center and (2) bus and light rail systems between the Tusayan gateway facility and the Mather Point center.

Public response to the draft assessment indicated (1) no day use parking should be provided at the Mather Point center, (2) all day use visitors, including tour buses, should park at the Tusayan gateway facility and ride a public transportation system to/from the Mather Point center, and (3) this public transportation system should be a light rail system.

Based on public concerns, conservation of resource values, and park management needs, this *Final Environmental Assessment* analyzes the impacts of taking no action, three alternatives, and the National Park Service's proposed action based on a light rail transportation system between the Tusayan gateway facility and the Mather Point center.

ALTERNATIVES

This *Final Environmental Assessment* includes three alternatives and the National Park Service's proposed action to implement the Mather Point orientation/transit center and transit system at the South Rim of Grand Canyon National Park. The alternatives and the proposed action differ in the configuration of the light rail service inside the South Rim. Development of the proposed action was supported with public comment on the draft assessment, which was released for a 30-day public review on March 17, 1997.

The proposed action for the Mather Point orientation/transit center and transit system is similar to alternative C (light rail) as described in the draft assessment. The principal differences between alternative C of the draft assessment and the proposed action of this final assessment are as follows:

- There would be no public parking (private vehicles or tour buses) at the Mather Point orientation/transit center; all parking would be provided at the Tusayan gateway facility.

- There would be a slightly reconfigured light rail route.

A light rail visitor transportation system would be developed between the Tusayan gateway facility and the Mather Point center. The differences among the alternatives and the proposed action is the light rail route within the village and South Rim bus service. Thus, each light rail route is presented and analyzed as a separate alternative.

It is important to note that there are significant differences between the cost estimates used for alternative C in the draft assessment (the light rail proposal submitted by Grand Canyon Railway) and all the light rail alternatives presented here. There are several reasons for this. First, the GCR estimate was an estimate of their cost meaning nonunion labor, agreements reached with rail car manufacturers, and excluding some engineering work they have already done. Additionally, it was assumed that savings could be found through the use of wood ties (rather than concrete) and used rail, each of which are less expensive than the more often estimated alternatives. In preparing the estimates in this document, NPS consultants were instructed to assume nationally recognized standards for material, labor, equipment, and engineering costs in recognition of the fact that the rail service being considered will be competitively bid. Therefore, it is assumed that new engineering and new materials will be used. At the time of contracting for the service, a determination will be made as to what standards will apply to that contract and bidders will bid accordingly. The NPS estimates also include rail stations, grade-separated crossings, and supplementary bus service, which were not included in the GCR estimate (per NPS request at the time).

Tables are included at the end of the "Alternatives" section that show comparison by alternative of year 2010 costs for transit system and shuttle bus, transportation cost per visitor, and environmental consequences.

NO-ACTION ALTERNATIVE

The no-action alternative would be the same as described in the draft assessment.

ELEMENTS COMMON TO ALL ACTION ALTERNATIVES

Introduction

This section describes the Mather Point Center and associated facilities that would be developed in all alternatives. Most day use visitors except those who have overnight reservations at the campground and lodges would be required to park at the Tusayan gateway facility and ride a transportation system into and out of Grand Canyon Village.

Description

As described in the draft assessment, Grand Canyon Village would be closed to private day use vehicles and tour buses. However, visitors who have overnight reservations at the campground and lodges would be allowed to drive into the village and park at Maswik where they would be transported to their room by the hotel or shuttled to other destination points on the South Rim.

An orientation center and transit hub would be constructed at Mather Point. The center would serve as a day use visitor transportation hub linking public transit services between the South Rim and Tusayan, and as a place for visitors to connect with transit services accessing various South Rim destinations.

There would be no public parking at the Mather Point center. All private vehicles and tour buses would park at the Tusayan gateway facility. Riders would then transfer to the light rail system and ride it to and from Mather Point. In all alternatives, no trains would be longer than two cars in order to keep the stations a reasonable length.

There would be a new grade-separated road overpass where Center Road would go over the light rail tracks at a location several hundred feet to the west of the junction of Center Road and the South Entrance Road. Although the alignment of Center Road would not change appreciably, the grade of the road would be modified. In order to create the overpass, Center Road would be raised up and over the tracks. Approximately 0.3 mile of Center Road would be removed and replaced. The modifications to Center Road would require that a short portion (300 feet) of Shuttle Bus Road be removed and replaced so that it matches the new elevation of Center Road.

There would be a new grade-separated road overpass where Shuttle Bus Road would go over the light rail tracks at a location just north of the maintenance area. About 0.37 mile of Shuttle

Bus Road would have to be removed and replaced at the new road grade. The alignment of Shuttle Bus Road would likely be modified slightly in the vicinity of the overpass structure.

A new 0.75-mile-long, two-lane road would be constructed from the Mather Point center and extend south toward the business center connecting to the existing road network in the vicinity of the Yavapai Lodge.

A new 0.3-mile-long, two-lane road would be constructed in the vicinity of the Mather Point center. This connection would provide access to the new facility from the existing South Entrance Road.

A new 0.85-mile-long, two-lane road would be constructed between the business center and Center Road. The road alignment would extend from Center Road east of the clinic to the northeast, connecting to the existing road network near the entrance to the campground.

As described in the draft assessment, existing South Rim shuttle bus service would be expanded and include routes on West Rim Drive and to Yaki Point/South Kaibab trailhead. Additional routes in the village are described in each alternative. However, all buses would use alternative fuels such as natural gas, batteries, or other source of electricity (e.g., fuel cells) eventually. The dry dump site would be used as a transportation vehicle maintenance area.

The intersection of South Entrance Road and East Rim Drive would be realigned to create the through traffic movement out to East Rim Drive. Existing paved portions of this intersection would be returned to natural conditions.

ALTERNATIVE 1

The Mather Point center, expanded bus service, dry dump vehicle maintenance yard, new access road from Center Road to the business center and campground, and realigned South Rim Road and East Rim Drive intersection would be constructed as described in the "Elements Common to All Action Alternatives" section.

Alternative 1 includes a 6.18-mile-long, double-track light rail passenger service operating between the Tusayan gateway facility and the Mather Point center. A 0.9-mile-long portion of South Entrance Road from Mather Point to near the intersection of Yavapai Observation Station overlook would be removed. Most of this road would be restored to natural conditions, although a small portion would be used to expand the existing Mather Point overlook.

A fleet of buses operating on several fixed routes would be used to provide visitor circulation within the village. Both the light rail and the bus service would operate year-round. South Rim visitors would park at the Tusayan gateway facility and ride the light rail system to access Mather Point, then ride the bus system to the village, and the West Rim. Overnight guest vehicles would be allowed on specific park roads to access their designated lodge parking area or campground. Tour buses with overnight guests would drive directly to their accommodations to unload passengers and luggage and return to Tusayan to park overnight. Tour buses with day use visitors would not be allowed access to Mather Point or the village. Day use tour buses would park at the Tusayan Gateway facility and passengers would ride the light rail system to the Mather Point center and the bus system within the South Rim. Buses providing point-to-point transportation services would use Maswik Transportation Center for pick-up and drop-off.

Light Rail System Requirements

Light Rail Route. The light rail portion of the transit system would operate between the Tusayan gateway facility and the Mather Point center. The roadbed for the light rail system would be located in a dedicated right-of-way. A double-track roadbed would be used for the entire system. The main line of the light rail system would be located to the west of and parallel to the South Entrance Road between Tusayan and Mather Point.

Light Rail Stations. As described in “Elements Common to All Action Alternatives,” there would be one station in the park, the Mather Point center. This station would be an at-grade, terminating (end-of-line) station.

Roadway/Light Rail Grade-Separated Crossings. These would be the same as described in “Elements Common to All Action Alternatives.”

Light Rail System Operation. Table 1 summarizes the light rail system requirements for each season for the years 2000 and 2010.

TABLE 1: LIGHT RAIL SYSTEM REQUIREMENTS - ALTERNATIVE 1

YEAR/SEASON	DEMAND	LIGHT RAIL VEHICLES REQUIRED (ROUTE REQUIREMENTS PLUS SPARES)	HEADWAY
2000 Summer	3,376 rides/hr.	8 + 2 = 10	5.75 minutes
2000 Shoulder	2,319 rides/hr.	6 + 2 = 8	7.66 minutes
2000 Winter	935 rides/hr.	3 + 2 = 5	7.66 minutes
2010 Summer	4,153 rides/hr.	10 + 3 = 13	4.6 minutes
2010 Shoulder	2,864 rides/hr.	8 + 2 = 10	5.75 minutes
2010 Winter	1,201 rides/hr.	3 + 2 = 5	7.66 minutes

Light Rail System Personnel Requirements. The personnel requirements have been estimated based on a rate of three employees per active light rail vehicle in operation during peak periods (with a minimum of 12 employees). This estimate covers drivers, mechanics, and administrative personnel. The personnel estimates in table 2 are based on the seasonal requirements in the years 2000 and 2010.

TABLE 2: LIGHT RAIL PERSONNEL REQUIREMENTS - ALTERNATIVE 1

YEAR/SEASON	MAXIMUM ACTIVE TRAINS	PERSONNEL REQUIRED
2000 Summer	8	24
2000 Shoulder	6	18
2000 Winter	3	12
2010 Summer	10	30
2010 Shoulder	8	24
2010 Winter	3	12

Light Rail Hours of Operation. The light rail system would operate seven days a week year-round. During the summer season (June-August) light rail service with maximum vehicle headways of about five to six minutes would be available between the hours of 6:00 A.M. and 10:00 P.M. Between the hours of 10:00 P.M. and 6:00 A.M. light rail service would be provided by a single vehicle operating on a one-hour frequency. A separate on-demand dial-a-ride taxi service would also be available for a fee from the concessioner between 10:00 P.M. and 6:00 A.M.

During the shoulder seasons (September-November and March-May) the light rail service would operate between the hours of 7:00 A.M. and 9:00 P.M. Maximum vehicle headways of about eight to ten minutes would be maintained during the day the same as during the summer season. Evening light rail service between the hours of 9:00 P.M. and 7:00 A.M. would be similar to the summer night operation with hourly service.

During the winter season (December-February) the light rail service would be available between the hours of 7:00 A.M. and 8:00 P.M. Maximum vehicle headways of about 10 to 15 minutes would be maintained during the day. Evening light rail service between the hours of 8:00 P.M. and 7:00 A.M. would be similar to the summer night operation with hourly service.

Bus System Requirements

Bus System Route. In addition to the bus service that is common to all alternatives (West Rim Drive, Yaki Point/South Kaibab trailhead), this alternative includes additional buses operating on four other fixed routes as described below.

Mather-Yavapai Museum Route
3.0-mile round-trip route (25 mph average speed)
2 stops (2 min/stop) – Mather Point and Yavapai Museum
12-minute round-trip travel time

Business Center Loop Bus Route
2.2-mile round-trip route (20 mph average speed)
5 stops (1 min/stop) – business center, Yavapai Lodge, Yavapai East, campground, and RV park
12-minute round-trip travel time

Village Loop Bus Route
1.75-mile route (20 mph average speed)
6 stops (1 min/stop) – El Tovar, Bright Angel, West Rim interchange, Maswik Lodge, Maswik Transportation Center, and Heritage Campus
12-minute round-trip travel time

Mather – Village Route
4.5-mile-round trip route (25 mph average speed)
3 stops (2 min/stop) – Maswik Transportation Center, business center, and Mather Point
17- minute round-trip travel time

Bus System Operation. A fleet of buses would provide for the visitor transportation needs in those areas of the village that are not served directly by the light rail system. To meet the projected year 2010 summer demand the bus fleet would likely consist of 34 (28 active + 6 spares) 50-passenger buses and 5 (4 active + 1 spare) 25-passenger buses. A total of 39 buses (32 active + 7 spares) would be required.

The smaller buses would be used on the route serving Yavapai Observation Station, while the larger buses would be used on all the other routes included in this alternative. All the buses in the fleet would be designed to have a low floor (14 inches or less) with wide doors opening on the right side of the vehicle.

Bus System Personnel Requirements. About 112 employees would be needed to operate the bus system in the summer season by the year 2010.

Bus System Hours of Operation. The bus system would operate seven days a week year-round. Bus service would be available between the hours of 6:00 A.M. and 10:00 P.M. during the summer, 7:00 A.M. and 9:00 P.M. during the shoulder season, and 7:00 A.M. and 8:00 P.M. during the winter. Vehicle headways would vary depending on the route and season. In most cases the headways would always be 20 minutes or less. A separate on-demand dial-a-ride taxi service would be available for a fee from the concessioner during the night after the bus service has ended.

ALTERNATIVE 2

In addition to the developments, restorative actions, and South Rim shuttle buses and hours of operation proposed in alternative 1, this alternative includes a 2.67-mile-long, double-track light rail passenger service operating between the Mather Point Center and Maswik making the total amount of double track 8.85 miles. A small station would be developed at the business center to load and unload passengers. The passenger boarding deck and a portion of the tracks at the existing train station at Maswik would be remodeled to accept the light rail. South Rim visitors would park at the Tusayan gateway facility and ride the light rail system to access the Mather Point center, through the business center, then on to Maswik.

Light Rail System Requirements

Light Rail Route. The light rail portion of the transit system would operate between the Tusayan gateway facility, the Mather Point center, on through the village, and then to Maswik. The roadbed for the light rail system between Tusayan and Mather Point would be located in a dedicated right-of-way located to the west of and parallel to the South Entrance Road. The light rail system would be located in the roadway (South Entrance Road) for much of the route between Mather Point and Maswik. A double-track roadbed would be used for the entire system.

Light Rail Stations. In this alternative, the light rail alignment has three stations in the park (the Mather Point center, the village business center, and Maswik). The Mather Point and village stations would be in-line stations, designed with loading platforms on both sides of each track. Because these are in-line stations, with through train traffic, visitors would cross the tracks to access some of the loading platforms. An at-grade pedestrian crossing of the tracks would be required in the design of these stations. The Maswik station would be a terminating (end-of-line) station and could be designed with loading platforms on both sides of each track without the need to have any pedestrians cross the tracks.

Roadway/Light Rail Grade-Separated Crossings. These would be the same as described in "Elements Common to All Action Alternatives."

Light Rail At-Grade Crossings. At-grade road crossings with the light rail system in this segment of the route would occur at two locations near the business center and at two locations on the village loop road. Traffic at three of the four crossing locations would be limited to park and concession personnel and park buses. In the short term, overnight guests would drive on the portion of the village loop that crosses the light rail line near Maswik Transportation Center. Eventually, a new access road is planned that would eliminate this crossing. Several high-use pedestrian paths would cross the light rail alignment in the vicinity of the business center and in the village.

Light Rail System Operation. Table 3 summarizes the light rail system requirements for each season for the years 2000 and 2010.

TABLE 3: LIGHT RAIL SYSTEM REQUIREMENTS - ALTERNATIVE 2

YEAR/SEASON	DEMAND	LIGHT RAIL VEHICLES REQUIRED (ROUTE REQUIREMENTS PLUS SPARES)	HEADWAY
2000 Summer	3,376 rides/hr.	16 + 3 = 19	6 minutes
2000 Shoulder	2,319 rides/hr.	12 + 3 = 15	8 minutes
2000 Winter	935 rides/hr.	5 + 2 = 7	9.6 minutes
2010 Summer	4,153 rides/hr.	20 + 4 = 24	4.8 minutes
2010 Shoulder	2,864 rides/hr.	14 + 3 = 17	6.9 minutes
2010 Winter	1,201 rides/hr.	6 + 2 = 8	8 minutes

Light Rail System Personnel Requirements. The personnel requirements have been estimated based on a rate of three employees per active light rail vehicle in operation during peak periods (with a minimum of 12 employees). This estimate covers drivers, mechanics, and administrative personnel. The personnel estimates in table 4 are based on the seasonal requirements in the years 2000 and 2010.

TABLE 4: LIGHT RAIL PERSONNEL REQUIREMENTS - ALTERNATIVE 2

YEAR/SEASON	MAXIMUM ACTIVE TRAINS	PERSONNEL REQUIRED
2000 Summer	16	48
2000 Shoulder	12	36
2000 Winter	5	15
2010 Summer	20	60
2010 Shoulder	14	42
2010 Winter	6	18

Light Rail Hours of Operation. The light rail hours of operation for this alternative would be the same as described for alternative 1.

Bus System Requirements

Bus System Route. In addition to the bus service that is common to all alternatives (West Rim Drive, Yaki Point/South Kaibab trailhead), this alternative includes additional buses operating on three other fixed routes as described below.

Mather-Yavapai Museum Route
3.0-mile round-trip route (25 mph average speed)
2 stops (2 min/stop) – Mather Point and Yavapai Museum
12-minute round-trip travel time

Business Center Loop Bus Route
2.2-mile round-trip route (20 mph average speed)
5 stops (1 min/stop) – business center, Yavapai Lodge, Yavapai East, campground, and RV park
12-minute round-trip travel time

Village Loop Bus Route
1.75-mile route (20 mph average speed)
6 stops (1 min/stop) – El Tovar, Bright Angel, West Rim interchange, Maswik Lodge, Maswik Transportation Center, and Heritage Campus
12-minute round-trip travel time

Bus System Operation. A fleet of buses would provide for the visitor transportation needs in those areas of the village that are not served directly by the light rail system. To meet the projected year 2010 summer demand the bus fleet would likely consist of eight (6 active + 2 spares) 50-passenger buses and five (4 active + 1 spare) 25-passenger buses. A total of 13 buses (10 active + 3 spares) would be required.

The smaller buses would be used on the route serving Yavapai Observation Station, while the larger buses would be used for all the other routes in this alternative. All the buses in the fleet would be designed to have a low floor (14 inches or less) with wide doors opening on the right side of the vehicle.

Bus System Personnel Requirements. About 35 employees would be needed to operate the bus system in the summer season by the year 2010.

Bus System Hours of Operation. The bus system hours of operation for this alternative would be the same as described for alternative 1.

ALTERNATIVE 3

The Mather Point center, expanded bus service, dry dump vehicle maintenance yard, new access road from Center Road to the business center and campground, realigned South Rim Road and East Rim Drive intersection, development of the village business center light rail station, and remodeling of the Maswik train station loading platform and train tracks would be constructed as described in alternative 2.

Alternative 3 includes a light rail passenger service operating between the Tusayan gateway facility, the Mather Point center, the village business center, and Maswik. A fleet of buses operating on several fixed routes would be used to provide visitor circulation within the Village. Both the light rail and the bus service would operate year-round.

All day use visitors to the village would park at the Tusayan gateway facility and ride the light rail system to access Mather Point and the village. Overnight guest vehicles would be allowed on specific park roads for the sole purpose of accessing their designated lodge parking area or campground. Tour buses would not be allowed access to Mather Point or the village. Tour buses would park at the Tusayan gateway facility and passengers would ride the light rail system into the South Rim at the Mather Point center or Maswik. Once inside the South Rim, visitors would ride the shuttle bus system in order to visit specific points. Buses providing point-to-point transportation services would use the Maswik Transportation Center for pick-up and drop-off.

Light Rail System Requirements

Light Rail Route. The light rail portion of the transit system would operate between Tusayan, Mather Point, and the village. The route would include a double-track line between Tusayan and Center Road where the tracks split to create a counter-clockwise single-track loop with stations at Mather Point, the business center, and Maswik. The roadbed for the light rail system between Tusayan and Mather Point would be located in a dedicated right-of-way located to the west of and parallel to the South Entrance Road. The light rail system would be located in the roadway (South Entrance Road) for much of the route between Mather Point and the village. From Maswik back to the junction near the South Entrance Road/Center Road intersection the rail alignment would be a dedicated right-of-way on the south side and generally parallel to Center Road. Rail sidings would be provided at each of the stations in the park for failure management. These sidings would enable a stalled rail vehicle to be pushed out of the way in the event of a breakdown.

Light Rail Stations. The alignment has four stations (Tusayan, Mather Point, business center, and Maswik), all of which would be at-grade stations. The Tusayan station would be a terminating (end-of-line) station and could be designed with loading platforms on both sides of each track without the need to have any pedestrians cross the tracks. The Mather Point, business center, and Maswik Stations would be in-line stations. These stations would be equipped with a rail siding so that there would be two sets of tracks going through each station. This feature is necessary for system failure management. These sidings and their switching would allow the system to continue to operate on portions of the single-track loop when one section of the loop is closed due to a disabled vehicle or track maintenance. These stations would be designed with loading platforms on both sides of each track. Because these are in-line stations, with through train traffic, the visitors would be required to cross the tracks to access some of the loading platforms. An at-grade pedestrian crossing of the tracks would be required in the design of these stations.

Roadway/Light Rail Grade-Separated Crossings. These would be the same as described in "Elements Common to All Action Alternatives."

Light Rail At-Grade Crossings. Light rail at-grade crossings for this alternative would be the same as described for alternative 2.

Light Rail System Operation. Table 5 summarizes the light rail system requirements for each season for the years 2000 and 2010.

TABLE 5: LIGHT RAIL SYSTEM REQUIREMENTS - ALTERNATIVE 3

YEAR/SEASON	MAIN LINE DEMAND	LIGHT RAIL VEHICLES REQUIRED (MAIN LINE + LOCAL + SPARES)	MAIN LINEHEADWAY
2000 Summer	3,376 rides/hr.	14 + 2 + 3 = 19	5.7 minutes
2000 Shoulder	2,319 rides/hr.	10 + 2 + 2 = 14	8 minutes
2000 Winter	935 rides/hr.	4 + 2 + 1 = 8	10 minutes
2010 Summer	4,153 rides/hr.	16 + 2 + 4 = 22	5 minutes
2010 Shoulder	2,864 rides/hr.	12 + 2 + 3 = 17	6.7 minutes
2010 Winter	1,201 rides/hr.	5 + 2 + 2 = 9	8 minutes

Light Rail System Personnel Requirements. The personnel requirements have been estimated based on a rate of three employees per active light rail vehicle in operation during peak periods (with a minimum of 12 employees). This estimate covers drivers, mechanics, and administrative personnel. The personnel estimates presented in table 6 are based on the seasonal requirements in the years 2000 and 2010.

TABLE 6: LIGHT RAIL PERSONNEL REQUIREMENTS - ALTERNATIVE 3

YEAR/SEASON	MAXIMUM ACTIVE TRAINS	PERSONNEL REQUIRED
2000 Summer	16	48
2000 Shoulder	12	36
2000 Winter	6	18
2010 Summer	18	54
2010 Shoulder	14	42
2010 Winter	7	21

Light Rail Hours of Operation. The light rail hours of operation for this alternative would be the same as described for alternative 1.

Bus System Requirements

Bus System Route. In addition to the bus service that is common to all alternatives (West Rim Drive, Yaki Point/South Kaibab trailhead), this alternative includes additional buses operating on three other fixed routes as described below.

Mather-Yavapai Museum Route
3.0-mile round-trip route (25 mph average speed)
2 stops (2 min/stop) – Mather Point and Yavapai Museum
12-minute round-trip travel time

Business Center Loop Bus Route
2.2-mile round-trip route (20 mph average speed)
5 stops (1 min/stop) – business center, Yavapai Lodge, Yavapai East, campground, and RV park
12-minute round-trip travel time

Village Loop Bus Route
1.75-mile route (20 mph average speed)
6 stops (1 min/stop) – El Tovar, Bright Angel, West Rim interchange, Maswik Lodge, Maswik transportation center, and Heritage Campus
12-minute round-trip travel time

Bus System Operation. A fleet of buses would provide for the visitor transportation needs in those areas of the village that are not served directly by the light rail system. To meet the projected year 2010 summer demand, the bus fleet would likely consist of eight (6 active + 2 spares) 50-passenger buses and five (4 active + 1 spare) 25-passenger buses. A total of 13 buses (10 active + 3 spares) would be required.

The smaller buses would be used on the route serving Yavapai Observation Station, while the larger buses would be used on all the other routes in this alternative. All the buses in the fleet would be designed to have a low floor (14 inches or less) with wide doors opening on the right side of the vehicle.

Bus System Personnel Requirements. About 35 employees would be needed to operate the bus system in the summer season by the year 2010.

Bus System Hours of Operation. The bus system hours of operation for this alternative would be the same as described for alternative 1.

PROPOSED ACTION

The proposed action would include the Mather Point center, expanded bus service, dry dump vehicle maintenance yard, new access road from Center Road to the business center and campground, and realigned South Rim Road and East Rim Drive intersection as described previously in the "Elements Common To All Alternatives." A 0.9-mile-long portion of the South Entrance Road from Mather Point to near the intersection of Yavapai Observation Station overlook would be removed. Most of this road would be restored to natural conditions, although a small portion would be used to expand the existing Mather Point overlook.

The proposed action includes a light rail passenger service operating between the Tusayan gateway facility and two locations within the park — the Mather Point center and Maswik. A fleet of buses operating on several fixed routes would be used to provide visitor circulation within the village. Both the light rail and the bus service would operate year-round.

All visitors to the village would park at the Tusayan gateway facility and ride the light rail system to access Mather Point or Maswik. Overnight guest vehicles would be allowed on specific park roads for the sole purpose of accessing their designated lodge parking area or campground. Day use tour buses would not be allowed access to Mather Point or the village. Tour bus passengers would change over to the light rail system in order to visit Mather Point and all points to the west. Buses providing point-to-point transportation services would use the Maswik Transportation Center for pick-up and drop-off.

Light Rail System Requirements

Light Rail Route. The light rail portion of the transit system would operate between the Tusayan gateway facility, the Mather Point center, and Maswik. The roadbed for the light rail system would be located in a dedicated right-of-way. A double-track roadbed would be used for the majority of the system. The layout is shaped like the letter "Y." The stem starts near Tusayan and branches east to Mather Point and west to Maswik at a point near the intersection of South Entrance Road and Center Road. Primary vehicle flow would be from Tusayan to Mather to Maswik and back to Tusayan, although adjustment to this flow could be made as necessary by changing switches. The line to Maswik would be located to the south of and generally parallel to Center Road. The light rail track would connect to the existing Grand Canyon Railway train tracks in the Maswik area of the village.

Light Rail Stations. The preferred alignment has two stations in the park (Mather Point center and Maswik), and both would be at-grade terminal stations.

Roadway/Light Rail Grade-Separated Crossings. These would be the same as described in "Elements Common to All Action Alternatives."

Light Rail System Operation. Table 7 summarizes the light rail system requirements for each season for the years 2000 and 2010.

TABLE 7: LIGHT RAIL SYSTEM REQUIREMENTS - PROPOSED ACTION

YEAR/SEASON	DEMAND	LIGHT RAIL VEHICLES REQUIRED (ROUTE REQUIREMENTS PLUS SPARES)	HEADWAY
2000 Summer	3,376 rides/hr.	12 + 3 = 15	5.8 minutes
2000 Shoulder	2,319 rides/hr.	8 + 2 = 10	8.75 minutes
2000 Winter	935 rides/hr.	4 + 2 = 6	8.75 minutes
2010 Summer	4,153 rides/hr.	14 + 3 = 17	5 minutes
2010 Shoulder	2,864 rides/hr.	10 + 2 = 12	7 minutes
2010 Winter	1,201 rides/hr.	4 + 2 = 6	8.75 minutes

Light Rail System Personnel Requirements. The personnel requirements have been estimated based on a rate of three employees per active light rail vehicle in operation during peak periods. This estimate covers drivers, mechanics, and administrative personnel. The personnel estimates presented in table 8 are based on the seasonal requirements in the years 2000 and 2010.

TABLE 8: LIGHT RAIL PERSONNEL REQUIREMENTS - PROPOSED ACTION

YEAR/SEASON	MAXIMUM ACTIVE TRAINS	PERSONNEL REQUIRED
2000 Summer	12	36
2000 Shoulder	8	24
2000 Winter	4	12
2010 Summer	14	42
2010 Shoulder	10	30
2010 Winter	4	12

Light Rail Hours of Operation. The light rail hours of operation for this alternative would be the same as described for alternative 1.

Bus System Requirements

Bus System Route. In addition to the bus service that is common to all alternatives (West Rim Drive, Yaki Point/South Kaibab trailhead), the proposed action includes additional buses operating on four other fixed routes as described below.

Mather-Yavapai Museum Route
3.0-mile round-trip route (25 mph average speed)

2 stops (2 min/stop) – Mather Point and Yavapai Museum
12-minute round-trip travel time

Mather-Business Center Route
2.7-mile round-trip route (20 mph average speed)
6 stops (1 min/stop) – Mather Point and business center, Yavapai Lodge, Yavapai East, campground, and RV park
15-minute round-trip travel time

Village-Business Center Route
3.0-mile round-trip route (25 mph average speed)
2 stops (2 min/stop) – Maswik Transportation Center and business center
12-minute round-trip travel time

Village Loop Bus Route
1.75-mile route (20 mph average speed)
6 stops (1 min/stop) – El Tovar, Bright Angel, West Rim interchange, Maswik Lodge, Maswik Transportation Center, and Heritage Campus
12-minute round-trip travel time

Bus System Operation. A fleet of buses would provide for the visitor transportation needs in those areas of the village that are not served directly by the light rail system. To meet the projected year 2010 summer demand, the bus fleet would likely consist of 14 (11 active + 3 spares) 50-passenger buses and 5 (4 active + 1 spare) 25-passenger buses. A total of 19 buses (15 active + 4 spares) would be required

The smaller buses would be used on the route serving Yavapai Observation Station, while the larger buses would be used on all the other routes. All the buses in the fleet would be designed to have a low floor (14 inches or less) with wide door openings on the right side of the vehicle.

Bus System Personnel Requirements. About 53 employees would be needed to operate the bus system in the summer season by the year 2010.

Bus System Hours of Operation. The bus system hours of operation for this alternative would be the same as described for alternative 1.

MITIGATION MEASURES

Mitigation measures would be the same as described in the draft assessment.

TABLE 9: SUMMARY OF ELEMENTS COMMON TO ALL ACTION ALTERNATIVES

ELEMENT	DESIGN FEATURE
Mather Point orientation and transit center	22,280 square feet of combined floor space
Plazas/pedestrian walkways	23,700 to 31,600 square feet
Viewpoint (rim edge)	Expand from 500 to 1,100 feet
Transportation system maintenance area	Expand existing dry dump site
Internal roads	About 1.9 miles of new road segments
Grade-separated crossings	Two: one where Center Road would go over the light rail tracks at a location several hundred feet to the west of the junction of Center Road and the South Entrance Road, and the other where Center Road would go over the light rail tracks at a location just north of the maintenance area.
Intersection of South Entrance Road and East Rim Drive	The intersection would be realigned to create the through traffic movement out to East Rim Drive. Existing paved portions of this intersection would be returned to natural conditions.
Utilities	200,000-gallon reclaimed water tank located east of tank farm
Buses	All buses would use alternative fuels.
Light rail	No trains would be more than two cars long.

TABLE 10: COMPARISON BY ALTERNATIVE OF YEAR 2010 COSTS FOR TRANSIT SYSTEM AND SHUTTLE BUS

ELEMENT	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	PROPOSED ACTION
Construct business center light rail station	NA	$1.2 million	$1.2 million	NA
Remodel Maswik transportation center light rail station	NA	$1/2 million	$1.2 million	$1.2 million
Light Rail				
Annual operation and maintenance cost	$3,810,807	$7,117,110	$6,945,950	$5,008,960
Annual capital cost[1]	$5,770,441	$9,399,781	$8,680,186	$7,863,324
Bus Service				
Annual operation and maintenance cost	$5,995,444	$1,515,696	$1,515,696	$2,397,304
Annual capital cost	$253,300	$114,989	$114,989	$125,785

1. Annual capital costs do not include existing maintenance facilities and equipment.

NOTE: These figures do not include any development at the Tusayan gateway facility or the Mather orientation/transit facility. Capital costs include rolling stock, maintenance/administrative offices and buildings, road rehabilitation, and operating costs. Not included in capital costs are taxes, depreciation, housing costs, etc. Cost per visitor would be included in, not in addition to, the park entrance fee.

TABLE 11: COMPARISON BY ALTERNATIVE OF TRANSPORTATION COST PER VISITOR

	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	PROPOSED ACTION
2000 Light Rail	$1.63	$2.82	$2.70	$2.23
2000 Bus Service*	$1.49	$0.44	$0.44	$0.67
Total Year 2000	**$3.12**	**$3.26**	**$3.14**	**$2.90**
2010 Light Rail	$1.40	$2.41	$2.28	$1.88
2010 Bus Service*	$1.42	$0.43	$0.43	$0.61
Total Year 2010	**$2.82**	**$2.84**	**$2.71**	**$2.49**

* Includes bus fleet replacement costs.

TABLE 12: SUMMARY OF ENVIRONMENTAL CONSEQUENCES

IMPACT TOPIC	NO ACTION	IMPACTS COMMON TO ALL ACTION ALTERNATIVES	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	PROPOSED ACTION
Biotic Communities	Same as no action in draft assessment.	Approximately 22.4 acres of piñon/juniper habitat would be affected. Approximately 1.7 acres of currently disturbed habitat would be restored leaving a net impact of 20.7 acres. Some habitat fragmentation would occur. Overall populations of affected species would be slightly and temporarily lowered during construction; however, once construction was completed and mitigation measures employed, population levels would be expected to recover to some degree. Additionally, landscaping and currently impacted areas that would be restored to natural conditions would provide new wildlife habitat. Minor short-term impacts on local water quality may occur during construction; however, measures would be taken to minimize impacts. No impacts on any special status species or critical habitats would occur.	An additional 54 acres of piñon/juniper woodland and some Ponderosa pine habitat would be disturbed for construction of a light rail transportation corridor and grade crossings. Thus, the total amount of area affected by alternative 1, including the 20.7 acres in "Impacts Common to All Action Alternatives," would be approximately 74.7 acres. However, it is not anticipated effects on biotic communities, community members, or biotic processes would be appreciable when viewed in context of the entire South Rim habitat.	An additional 70.75 acres of piñon/juniper woodland and some Ponderosa pine habitat would be disturbed by construction in this alternative. Thus, the total amount of area affected by alternative 2, including the 20.7 acres in "Impacts Common to All Action Alternatives," would be approximately 91.45 acres.	An additional 78.6 acres of piñon/juniper woodland and some Ponderosa pine habitat would be disturbed by construction in this alternative. Thus, the total amount of area affected by alternative 3, including the 20.7 acres in "Impacts Common to All Action Alternatives," would be approximately 99.3 acres.	An additional 75 acres of piñon/juniper woodland and some Ponderosa pine habitat would be disturbed by construction in this alternative. Thus, the total amount of area affected by the proposed action, including the 20.7 acres in "Impacts Common to All Action Alternatives," would be approximately 95.7 acres.
Air Quality	Same as no action in draft assessment.	Short-term, minor impacts on air quality would occur during construction. However, measures would be implemented to reduce impacts of fugitive dust during construction (see the "Mitigation Measures" section of draft assessment). Reductions in emissions that affect air quality over the Grand Canyon would be the result of any of the transportation alternatives.	Implementation of a light rail system would have long-term benefits on air quality. The cleanest affordable fuel would be specified. Use of alternative fuel buses and elimination of private vehicles on the South Rim would have long-term beneficial impacts on air quality.	Same as alternative 1.	Same as alternative 1.	Same as alternative 1.

IMPACT TOPIC	NO ACTION	IMPACTS COMMON TO ALL ACTION ALTERNATIVES	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	PROPOSED ACTION
Noise	Same as no action in draft assessment.	There would be some reduction in traffic noise from private vehicle traffic. Additionally, the long-term impacts on noise levels from implementation of a light rail system would be beneficial due to overall reduction in vehicular traffic.	The long-term impacts on noise levels from implementation of a light rail system and expanded visitor bus shuttle would be less than present conditions due to overall reduction in vehicular traffic.	Sounds of the light rail as it traveled through the village and the alarms of the two at-grade light rail crossings would be heard by visitors in the village and rim areas. However, when viewed in context of the existing sounds of the village noise levels and frequencies would be less.	Same as alternative 2.	Same as alternative 1; however, for the year 2010 summer season a fleet of 15 shuttle buses would be required. This is slightly less than half the number of shuttle buses required for alternative 1.
Cultural Resources	Same as no action in draft assessment.	Three archeological sites would be destroyed by the construction of the Mather Point orientation and transit center. An additional six sites could be directly affected by construction activities more could be disturbed by construction activities, road realignment, and increased visitor use of the area. Elements of the cultural landscape could be lost through redesign of the Mather Point overlook. Through avoidance in design or mitigation, it is anticipated that the effect would not be adverse. Decreased vehicular congestion and quieter surroundings would have a beneficial effect on the Grand Canyon Village Historic District.	Construction of a dedicated light rail line between Tusayan and Mather Point and revegetation of South Rim Drive from Mather Point to the visitor center could disturb as many as 25 archeological sites, depending on design.	The proposed routing of light rail would intrude on the scene of the Grand Canyon Village Historic District, and a section of the historic stone wall would be lost. A total of 30 sites could be disturbed by the construction of a dedicated transportation corridor. It is anticipated that any impacts on archeological sites would be avoided through design or mitigation. However, impacts on the Grand Canyon Village Historic District would likely be adverse.	As many as 37 archeo-logical sites could be disturbed by construction of a dedicated trans-portation corridor. Routing of the light rail corridor would have impact on Grand Canyon Village Historic District. It is anticipated that any impact on archeological sites would be avoided through design or mitigated. However, impacts on the Grand Canyon Village Historic District would likely be adverse.	At least 32 archeological sites could be disturbed by construction of a dedicated light rail corridor and revegetation of approximately 1 mile of South Rim Drive. Through avoidance in design or mitigation, the effects would not be adverse. The routing of the light rail corridor along Center Road would not intrude on the historic scene of Grand Canyon Village Historic District

IMPACT TOPIC	NO ACTION	IMPACTS COMMON TO ALL ACTION ALTERNATIVES	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	PROPOSED ACTION
Visitor Experience	Same as no action in draft assessment.	Over the short term, the visitor experience would be adversely affected by noise, dust, fumes, delays, and construction vehicle traffic for the duration of construction activities. Over the long term, the function of South Rim roads would be restored to the purpose of providing a safe, leisurely, and enjoyable route for relaxed sightseeing. By receiving orientation and interpretation early in their visit at the Mather Point orientation and transit center, visitors would be able to tailor their visit with their needs by choosing from a variety of transit routes leading to various park destinations. Summer visitors would experience less congestion than currently experienced.	Visitors may experience some inconvenience waiting for the light rail; however, trains would depart the Tusayan Gateway facility for the Mather Point center at least every 10 to 15 minutes in peak summer season. The light rail transportation and the South Rim shuttle bus costs for each visitor in the year 2000 would decrease in the year 2010. Overall impacts on the visitor experience would be beneficial.	Impacts would be similar to alternative 1. However, the light rail transportation and South Rim shuttle bus costs for each visitor in the year 2000 would decrease by the year 2010. Overall impacts on the visitor experience would be beneficial.	Impacts would be similar to alternative 1; however, the light rail transportation and South Rim shuttle bus costs for each visitor in 2000 would decrease in 2010. Overall impacts on the visitor experience would be beneficial.	Impacts would be similar to alternative 1. However, the light rail transportation cost for each visitor in 2000 would decrease in the year 2010, and the South Rim shuttle bus cost for each visitor in 2000 would decrease in 2010. Overall impacts on the visitor experience would be beneficial.
Scenic Values	Same as no action in draft assessment.	No adverse impacts would be expected, although the Mather Point scenery would be changed. New facilities would blend with and complement existing environments and vistas. Building design and color scheme, plantings around the structures, and spatial orientation would all reduce the visibility and enhance the appearance of the structures. Views of the Grand Canyon would be enhanced over the long term. Views of Mather Point from the North Rim and from within the canyon would not be affected.	For much of its length the light rail corridor would be screened by tall trees and dense forest, and impacts on scenic values are not expected to be appreciable.	Same as alternative 1.	Same as alternative 1.	Same as alternative 1.

IMPACT TOPIC	NO ACTION	IMPACTS COMMON TO ALL ACTION ALTERNATIVES	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	PROPOSED ACTION
Traffic Management	Same as no action in draft assessment.	Impacts on visitor traffic during construction would be mitigated by those actions described in the "Mitigation Measures" section of the draft assessment. Over the long term, traffic problems in the South Rim and Grand Canyon Village would be greatly reduced. Since the Grand Canyon Village would be closed to day use, private automobile traffic year-round, the roads would be operating below their capacity, congestion would be abated considerably, and the South Rim road system would be expected to function at LOS B or better.	Overall impacts on traffic management and safety would be minor.	Same as alternative 1.	Same as alternative 1.	Same as alternative 1.
Park/Transit Operations	Same as no action in draft assessment.	Park operations would be greatly helped. The roads would remain serviceable for several decades without major maintenance needs; time spent by park staff conducting road repairs would be reduced.	Implementation of the light rail would provide a single system of traffic movement to and from the South Rim.	Same as alternative 1.	Same as alternative 1.	Same as alternative 1.

ENVIRONMENTAL CONSEQUENCES

This section describes the environmental consequences associated with no action and the action alternatives. It is organized by impact topics, which distill the issues and concerns into distinct topics for discussion. These topics focus the presentation of environmental consequences and allow a standardized comparison among no action and the action alternatives based on the most relevant topics. (See the “Issues and Impact Topics” section under “Impact Topics Addressed” in the draft assessment for further discussion.)

All action alternatives in this document implement a portion of phase 1 of the approved 1995 *General Management Plan* and were developed in response to public input on the draft assessment.

The environmental consequences of implementing any of the action alternatives in this document should not be viewed as an individual event, isolated to a single point on the South Rim. Implementing any of the action alternatives would be the first of many correlated actions throughout the park, and should be viewed in a parkwide context. Please review the environmental consequences section of the proposed action in the 1995 *Draft General Management Plan / Environmental Impact Statement* (p. 224) for a complete description of the environmental consequences.

Lastly, only those environmental consequences associated with the four action alternatives for the Mather Point center have been analyzed in this document. As described in the draft assessment, the environmental consequences for the Tusayan gateway facility and that portion of the transportation corridor between the Tusayan gateway facility and the park’s southern boundary are presented in the U.S. Forest Service’s *Draft Environmental Impact Statement for Tusayan Growth*.

IMPACTS OF NO-ACTION ALTERNATIVE

The impacts on biotic communities, air quality, noise, cultural resources, visitor experience, scenic values, traffic management, and park operations would be the same as the no action in the draft assessment.

IMPACTS COMMON TO ALL ACTION ALTERNATIVES

Biotic Communities

Analysis. To construct the Mather Point Center with the buildings, visitor loading/unloading areas, plazas, trails, water tank, new access roads, two separated grade crossings, and realigning the junction of South Entrance Road and East Rim Drive would disturb about 22.4

acres of piñon/juniper habitat. However, some of the facilities would be constructed on previously disturbed areas (e.g., utility corridors, old roadbeds, burned areas).

About 1.7 acres of previously disturbed piñon/juniper habitat would be restored to natural conditions by the realignment of the junction of South Entrance Road and East Rim Drive.

Facilities proposed for the vehicle maintenance area would be constructed at the 30-acre dry dump area. Facilities would include a helibase operation, garages, fuel storage and fueling capabilities, administrative offices, and other similar functions. The existing dry dump site would be for helibase operations while the other facilities would be expanded to the east. The area affected for the eastward expansion would be about 13.5 acres and was analyzed in the *Final General Management Plan / Environmental Impact Statement* (p. 52).

Most impacts on vegetation and soils would be caused by constructing buildings, parking areas, trails, roads, and other similar facilities or removing such facilities and the subsequent restoration of the vacated area. An additional area, the construction zone surrounding each project site, would also be disturbed; soils would be exposed and some vegetation would be removed. However, impacts on soils, particularly within the construction zones, would be mitigated by defining the construction zones with construction tape or fencing, and installing soil erosion devices and measures as described in the “Mitigation Measures” section of the draft assessment.

Impacts on soils from construction include trampling, digging for foundations, road base preparation and cuts and fills, and some soils would be covered with impermeable materials such as buildings, asphalt, and concrete. Surface soil horizons would be altered, topsoil would be removed, and some soil would be compacted and compressed. These consequences would result in a localized decrease in soil permeability to water and air, alteration of soil regime, and an increase in localized runoff and channelization. These effects would be mitigated as described in the “Mitigation Measures” section of the draft assessment. In some areas, a number of facilities or structures would be removed or relocated. Once the structure is removed, the site would be returned to natural conditions by scarification, which decompacts the soil; the site topography would be returned to its preconstruction contours. The site may either be allowed to revegetate itself naturally or it could be revegetated with species native to the immediate area. Revegetation would facilitate soil stability, help to reduce runoff, channelization, and erosion, and help the soil to restore itself to natural conditions.

Indirect impacts on vegetation can be expected as the result of compacted soils. Plant seedlings generally fail to penetrate compacted soil and usually die before becoming established. Also, water and air do not percolate well through compacted soils; lack of water and air in soil also contributes to increased seedling mortality. Indirect impacts on vegetation would also result from foot traffic. Foot traffic to and around buildings and visitors wandering off established trails would trample vegetation thus damaging or killing seedlings and similar small plants.

Most impacts would occur within the piñon/juniper habitat, although some impacts on the big sagebrush habitat would also be expected. These habitats are abundant throughout the park and the region, and the loss of 18 acres of these habitats would result in no appreciable effect on the overall communities or their species composition.

Vegetation would be removed from the building sites. Other vegetation would be trimmed and thinned within 30–100 feet of each structure to reduce wildfire hazard. Drought-tolerant and fire-resistant species would be used to landscape or revegetate areas around structures.

Piñon/juniper and big sagebrush habitats are common habitats found throughout the region and on the South Rim; most of the existing South Rim developments have occurred in these habitats. As a result of these development actions, some degree of habitat fragmentation has already occurred.

Factors contributing to and influencing habitat fragmentation are difficult to measure and are not completely understood. Elements known to contribute to ecosystem fragmentation at Grand Canyon National Park include (1) reducing the size of “ecosystem islands” or continuous habitat areas, and (2) developing buildings, roads, fences, or trail barriers that prevent smaller wildlife species such as amphibians and reptiles from moving from area to area. It is anticipated that the loss of wildlife would be proportional to the amount of habitat lost. Portions of the project site have been previously affected because of periodic fires, nearby utility corridors and roads, and attendant human activity. During construction some small animals might be killed or forced to relocate to areas outside the construction zone. Overall populations of affected species would be slightly and temporarily lowered during construction; however, once construction was completed and mitigation measures employed, population levels would be expected to recover to some degree. Additionally, landscaping and currently impacted areas that would be restored to natural conditions would provide new wildlife habitat.

Large zones of existing open space would be retained as landscaped areas within the developed environment; this would help maintain the environmental requirements necessary for native vegetation to thrive and reproduce and, therefore, aid in the preservation of natural habitats. Wildlife would thus be less affected by the continued existence of large, continuous areas of open space. Although construction would contribute to habitat fragmentation at Mather Point, the project area is small in scope when taken in context of the entire South Rim and similar habitats throughout the region. Therefore, the overall effect of construction and post-construction activities on wildlife populations at the South Rim would not be appreciable.

Development of the Mather Point center would expand the area of visitor/wildlife contact. It would be expected that the current visitor practice of illegally feeding animals, such as deer and squirrels, would continue. Such contact tends to domesticate some wildlife individuals, adversely affects natural wildlife behavior, and exposes visitors to an element of risk. Visitors would be discouraged from feeding wildlife through education and law enforcement.

Additionally, relocation of the domesticated wildlife individuals, as has been done in the village area, would continue.

As stated in the draft assessment, no special status species or critical habitats would be affected by implementing any of the alternatives; therefore, this topic is not analyzed further in this document.

Conclusion. Approximately 22.4 acres of piñon/juniper habitat would be affected. Approximately 1.7 acres of currently disturbed habitat would be restored leaving a net impact of 20.7 acres. Some habitat fragmentation would occur. Overall populations of affected species would be slightly and temporarily lowered during construction; however, once construction was completed and mitigation measures employed, population levels would be expected to recover to some degree. Additionally, landscaping and currently impacted areas that would be restored to natural conditions would provide new wildlife habitat. Minor short-term impacts on local water quality may occur during construction; however, measures would be taken to minimize impacts. There would be no impacts on any special status species or critical habitats.

Air Quality

Analysis. All action alternatives dictate a reduction in the amount of driving associated with private vehicles, especially in the village area. The typical visitor who stops at an overlook, drives to another and stops, drives to a restaurant and parks, etc., would be replaced by the typical visitor who parks once and then uses transit service. As private vehicular traffic is reduced and lower emission transit vehicles are encouraged, emissions affecting the quality of the air over the Grand Canyon would also be reduced.

Restricting day use vehicles from the South Rim would remove up to 80% of the traffic in the village, thereby improving park air quality over existing levels. Directing all village day use traffic to park at the Tusayan gateway facility would not be expected to increase emissions beyond present levels at or near the community of Tusayan because all vehicles parked there would already be traveling through Tusayan. Additionally, as described in the *Draft General Management Plan / Environmental Impact Statement* (p. 225), a number of actions would be implemented or encouraged to reduce air pollution inside the park. These actions include an increased emphasis on hiking, biking, and shuttle use; providing employee shuttles; and requiring buses to turn off their engines while waiting and loading/unloading passengers.

Should any of the action alternatives be selected, local air quality would be temporarily affected by dust and vehicle emissions. Hauling material and operating equipment during the construction period would result in increased vehicle exhaust and emissions. Hydrocarbons, NO_x, and SO_2 emissions would be rapidly dissipated by air drainage since air stagnation is rare at the project site.

Conclusion. Short-term, minor impacts on air quality during construction would occur. However, measures would be implemented to reduce impacts of fugitive dust during construction (see the “Mitigation Measures” section of the draft assessment). Reductions in emissions that affect air quality over the Grand Canyon would be the result of any of the transportation alternatives.

Noise

Analysis. Controversy regarding aircraft overflights and the effect of aircraft noise on the visitor experience points to the importance of attempting to reduce all noise sources, so it is important that rim sources of noise also be reduced or eliminated. As private vehicle traffic is reduced, noise from vehicles, within the canyon and on the rim, would also be reduced. Use of alternative fuel buses would eliminate the need for private vehicles and thereby reduce noise. Buses would use the latest technology to minimize noise impacts. Additionally, a light rail train operator would be encouraged or required to use quiet technology to minimize noise intrusions.

Conclusion. There would be some reduction in traffic noise from private vehicle traffic. Additionally, the long-term impacts on noise levels from implementation of a light rail system would be beneficial due to overall reduction in vehicular traffic.

Cultural Resources

Analysis. Archeological surveys are ongoing; thus, the number of given sites could increase depending on the results of those surveys.

Four archeological sites would be destroyed by the construction of the Mather Point orientation and transit center. An additional six archeological sites would be directly impacted by construction activities, road realignment, and increased visitor use of the area.

Expansion of the Mather Point overlook could result in the loss of elements of the cultural landscape, but it is anticipated that the impact would be minimized through design. Important design elements of the landscape such as an island of vegetation between open public spaces and the rim view area, private enclaves to provide intimate viewing spaces, use of field stone for curbing and low, curving stone walls that blend in with the surrounding landscape, and/or transparent safety railings would be retained in any new design.

Every effort would be made to avoid all cultural resources during any proposed construction activities. Should avoidance prove impossible or should unknown resources be uncovered during construction, the National Park Service would develop mitigation measures according to stipulations of the 1995 programmatic agreement among the National Park Service, Arizona state historic preservation officer, and Advisory Council on Historic Preservation regarding the *General Management Plan* for Grand Canyon National Park.

Although the National Park Service is consulting with tribal groups, the effects on ethnographic resources are unknown. The types of known archeological sites have not yielded burials on the South Rim in the past. However, there is always the potential that human remains may be encountered during construction activities. If specific memoranda of understanding have not been negotiated with tribes for treatment of human remains prior to construction, and if the tribes so request, the National Park Service would provide for American Indian monitors during ground-disturbing activities in the vicinity of these sites.

Conclusion. Three archeological sites would be destroyed by the construction of the Mather Point orientation and transit center. An additional six sites could be directly affected by construction activities, road realignment, and increased visitor use of the area. Elements of the cultural landscape could be lost through redesign of the Mather Point overlook. Through avoidance in design or mitigation, it is anticipated that the effect would not be adverse. Decreased vehicular congestion and quieter surroundings would have a beneficial effect on the Grand Canyon Village Historic District.

There would be no adverse effects on the cultural landscape. There would be an overall beneficial effect on the historic district from the decreased vehicular congestion and quieter surroundings.

Visitor Experience

Analysis. During construction activities, visitors using the South Entrance Road would be subjected to the increased commercial truck traffic hauling construction material, and noise, dust, and visual intrusion.

Construction vehicles associated with the project would contribute to already heavy traffic using the South Entrance and South Entrance Road. At times, summer visitors entering the park through the South Entrance would experience traffic delays due, in part, to construction vehicles sharing the South Entrance with visitor traffic. Although visitors caught in the delays would be frustrated and consider the delays interminable, major construction-related traffic delays would not be anticipated.

Parking at Yaki Point would be reserved for shuttle vehicles. This would eliminate competition for parking spaces and hazardous road conditions and create more pedestrian space and enhance the visitor experience at the overlooks.

Providing safe bike trails linking all major use areas and new rim trails would give visitors alternative ways to safely view the park and experience the resources. Shuttle vehicles would have bike racks.

The Mather Point center would provide orientation and introduction to all park themes. Visitors would benefit from a more conveniently located and centralized orientation and interpretive facility and generalized interpretation focusing on all park themes; point specific detailed interpretation would be provided at specific points throughout the park and accessed by transit service, walking, or biking.

The Mather Point site is within a principal vista viewing area and adjacent to the South Entrance Road, the primary park access route. The Mather Point viewing area would be closed to visitor use during the construction period. Over the short term, some visitors would be dissatisfied because they would be unable to experience the area due to construction; however, the area would be closed only as long as construction would occur. Once construction was completed, expanded interpretive and viewing opportunities would be provided, thus enhancing interpretation and vista viewing of this part of the Grand Canyon.

Conclusion. Over the short term, the visitor experience would be adversely affected by noise, dust, fumes, delays, and construction vehicle traffic for the duration of construction activities. Over the long term, the function of South Rim roads would be restored to the purpose of providing a safe, leisurely, and enjoyable route for relaxed sightseeing. By receiving orientation and interpretation early in their visit at the Mather Point orientation and transit center, visitors would be able to tailor their visit with their needs by choosing from a variety of transit routes leading to various park destinations. Summer visitors would experience less congestion than currently experienced.

Scenic Values

Analysis. At a distance of 200 feet south of the existing road at Mather Point, the siting of the Mather Point center would take advantage of the natural vegetative screening and a drop in grade to disguise the presence of the Grand Canyon. As visitors approached the rim, the anticipatory aspect of the site would thus be retained and enhanced, which would foster the elements of surprise and revelation at the rim. The views by visitors looking back from the rim would not reveal the development from which they came. Instead, the leisurely return walk would allow for passive reflection.

The Mather Point orientation and transit center would be screened as much as possible by existing vegetation and landscaping efforts. Overall design considerations include the Grand Canyon National Park's *Architectural Character Guidelines* to construct the facilities in a manner conducive and supportive of the natural environment. The Mather Point center would not be visible from other locations on the South or North Rims and no vistas would be altered.

Park guidelines and the Coconino County ordinance would be followed in the exterior lighting design. Exterior lighting would not be visible outside the immediate area.

Conclusion. No adverse impacts would be expected, although the Mather Point scenery would be changed. New facilities would blend with and complement existing environments and vistas. Building design and color scheme, plantings around the structures, and spatial orientation would all reduce the visibility and enhance the appearance of the structures. Views of the Grand Canyon would be enhanced over the long term. Views of Mather Point from the North Rim and from within the canyon would not be affected.

Traffic Management

Analysis. Impacts on visitor traffic during construction would be mitigated by those actions described in the “Mitigation Measures” section of the draft assessment.

Over the long term, traffic problems in the South Rim and Grand Canyon Village would be greatly reduced.

Since the Grand Canyon Village would be closed to day use, private automobile traffic year-round, the roads would be operating below their capacity, congestion would be abated considerably, and the South Rim road system would be expected to function at level of service (LOS) B or better. Shuttle transit service would experience minimal delays and would run on dependable and regular schedules.

Conclusion. Impacts on visitor traffic during construction would be mitigated by those actions described in the “Mitigation Measures” section of the draft assessment. Over the long term, traffic problems in the South Rim and Grand Canyon Village would be greatly reduced. Since the Grand Canyon Village would be closed to day use, private automobile traffic year-round, the roads would be operating below their capacity, congestion would be abated considerably, and the South Rim road system would be expected to function at LOS B or better.

Park/Transit Operations

Analysis. The processes of resource management and providing for a quality visitor experience would be appreciably enhanced. The South Rim roads would be closed to day use visitor traffic; this would reduce the amount of traffic and associated wear and tear on the roads. This would extend the service life of the roads by perhaps as much as several decades.

During the summer months, park protection rangers would spend less time assisting visitors who become involved in traffic accidents, are lost, parking illegally, or seeking information than under current conditions.

Conclusion. Park operations would be greatly helped. The roads would remain serviceable for several decades without major maintenance needs; time spent by park staff conducting road repairs would be reduced.

IMPACTS OF ALTERNATIVE 1

Please refer to appendix A for the methodologies related to the development of a visitor transit system under alternative 1.

Biotic Communities

Analysis. Impacts would be the same as described in "Impacts Common to All Action Alternatives." Additionally, the double-track light rail corridor running from the southern park boundary to the Mather Point center would be 6.18 miles long and disturb approximately 54 acres. Therefore, the area affected by light rail construction in this alternative would be about 54 acres, most of which would occur in piñon/juniper habitat, although some Ponderosa pine habitat would be affected.

For much of its length, however, the light rail route would be constructed on abandoned roads, previously impacted areas, and along utility corridors thereby minimizing impacts. Impacts on the vegetative component of the biotic community would be principally on immature piñon, juniper, and understory species.

Impacts on wildlife from constructing and using the transportation corridor would be to further reduce and fragment available habitat. The corridor would create another obstruction for wildlife movement in the area; some wildlife kills would be expected but with no more frequency than what now takes place in the park. However, it is not anticipated the effects on biotic communities, community members, or biotic processes would be appreciable when viewed in context of the entire South Rim habitat.

Conclusion. An estimated 54 acres of piñon/juniper woodland and some Ponderosa pine habitat would be disturbed for construction of a light rail transportation corridor and grade crossings. Thus, the total amount of area affected by alternative 1, including the 20.7 acres in "Impacts Common to All Action Alternatives," would be approximately 74.7 acres. However, it is not anticipated the effects on biotic communities, community members, or biotic processes would be appreciable when viewed in context of the entire South Rim habitat.

Air Quality

Analysis. Impacts would be the same as described in "Impacts Common to All Action Alternatives." Additionally, implementation of a light rail system would reduce the number of total vehicles in operation. Although new diesel engines are cleaner than ever, diesel would not be as clean as natural gas fuel, which might be available for light rail cars. Electric light rail cars would be even less polluting at the local level but are not evaluated here because initial infrastructure costs are substantial. Emissions from a light rail system, regardless of fuel, would not have adverse impacts on air quality.

Alternative fuel buses for the South Rim shuttle service would be used to reduce vehicle emissions, resulting in a significant reduction in air quality impacts when compared to existing conditions. Quantitative data are not available to determine the total reduction in emissions.

Conclusion. In addition to those impacts that are common to all action alternatives, implementation of a light rail system would have long-term benefits on air quality. The cleanest affordable fuel would be specified. Use of alternative fuel buses and elimination of private vehicles on the South Rim would have long-term beneficial impacts on air quality.

Noise

Analysis. Impacts would be the same as described in “Impacts Common to All Action Alternatives.” Additionally, the light rail train would operate with the latest technology to minimize noise intrusions. The system would be a contributing factor to reduce the number of vehicles in the park and therefore have reduced levels of noise impacts. For the foreseeable future, light rail cars without overhead electric wires would be powered by internal combustion engines, which are noisy. If fuel cell or other on-board electric options become feasible, conversion would be considered. Use of alternative fuel buses for the South Rim shuttle would also reduce the need for private vehicles and thereby reduce noise. Buses would use the latest technology to minimize noise impacts. For the year 2010 summer season, a fleet of 32 shuttle buses with an average headway of 4 minutes would generate noise in the South Rim and village. However, when viewed in context of the existing sounds of automobiles, tour buses, the Grand Canyon Railway train, and the railroad tracks’ audible at-grade traffic warning alarms that are currently a common and accepted noise experience in the South Rim and village, noise levels and frequencies would be less because day-use automobiles would be removed from the village area.

Conclusion. In addition to those impacts that are common to all action alternatives, the long-term impacts on noise levels from implementation of a light rail system and expanded visitor bus shuttle would be less than present conditions due to overall reduction in vehicular traffic.

Cultural Resources

Analysis. Impacts would be the same as described in “Impacts Common to All Action Alternatives.” In addition, construction of a dedicated light rail line between Tusayan and Mather Point and revegetation of South Rim Drive from Mather Point to the visitor center could disturb as many as 25 archeological sites.

Conclusion. In addition to those impacts that are common to all alternatives, a total of 25 archeological sites could be disturbed, depending on design.

Visitor Experience

Analysis. Impacts would be the same as described in "Impacts Common to All Action Alternatives." Additionally, public transportation for day use visitors would be provided by light rail between the Tusayan gateway facility and the Mather Point center, which would depart every 10 to 15 minutes; however, some visitors may experience some inconvenience waiting for the light rail. The light rail cars are spacious, employ level loading at all stops, include interior bike racks, and can be fitted with a video system; visitors would experience a high degree of comfort and convenience riding them. In the year 2000 there would be a $1.63 transportation cost for each visitor; this fee would drop to $1.40 in the year 2010.

From the Mather Point orientation and transit center visitors would catch South Rim shuttle buses to their South Rim destinations, or they could hike or bike. By removing private vehicles and tour buses from the South Rim and providing shuttles running on regular and dependable schedules, summer visitors would no longer face the confusion, congestion, and frustration of overcrowded roads and parking areas.

In the year 2000 there would be a $1.49 transportation cost for each visitor for the shuttle service; this fee would decrease to $1.42 in the year 2010. The transportation cost of the light rail and South Rim shuttle bus service would be included in the park entrance fee.

Conclusion. In addition to those impacts that are common to all action alternatives, visitors may experience some inconvenience waiting for the light rail; however, trains would depart the Tusayan Gateway facility for the Mather Point center at least every 10 to 15 minutes in peak summer season. Visitors that choose not to hike to bike would be required to use the shuttle bus system to access the village. The light rail transportation cost for each visitor in the year 2000 would decrease in the year 2010, and the South Rim shuttle bus cost for each visitor in 2000 would decrease in 2010.

Scenic Values

Analysis. Impacts would be the same as described in "Impacts Common to All Action Alternatives." Additionally, the light rail corridor, and the frequently run light rail itself, up to Mather Point and looping through the village, may be perceived as a visual intrusion. For much of its length, however, the corridor would be screened by tall trees and dense forest and impacts on scenic values are not expected to be appreciable. Where the light rail would travel through Grand Canyon Village, it would be another element in the built, essentially urban environment. Impacts would be minor through the corridor.

Conclusion. In addition to those impacts that are common to all action alternatives, impacts would on scenic values be minor through the light rail corridor.

Traffic Management

Analysis. Impacts would be the same as described in “Impacts Common to All Action Alternatives.” Additionally, the light rail would not be sharing the transportation route with the village roads. The light rail crossings would pass under the roads and present no traffic conflicts.

Conclusion. In addition to those impacts that are common to all action alternatives, impacts on traffic management and safety resulting from alternative 1 would be minor.

Park/Transit Operations

Analysis. Impacts would be the same as described in “Impacts Common to All Action Alternatives.” Additionally, approximately 30 people would be needed to operate the light rail system during the summer peak season of 2010, and a total of 13 light rail cars (10 operational + 3 spares) would be needed for operation of the system. For the year 2010, the estimated total annual cost, including capital and operations and maintenance, for the light rail system would be $9.6 million. Approximately 112 people would be needed to operate the shuttle bus system during the summer peak season of the year 2010 and a total of 39 buses (32 active + 7 spares) would be needed for operation of the system. For the year 2010, the estimated total annual cost for the shuttle bus system, including operations and maintenance, capital, and rolling stock fee, would be $7.6 million.

Conclusion. Long-term impacts on park operations would be beneficial. Implementation of the light rail would provide a single system of traffic movement to and from the South Rim.

IMPACTS OF ALTERNATIVE 2

Please refer to appendix B for the methodologies related to the development of a visitor transit system under alternative 2.

Biotic Communities

Analysis. Impacts would be the same as described in “Impacts Common to All Action Alternatives.” In addition, construction of the village business center light rail station would disturb approximately 0.5 acre; and remodeling of the Maswik light rail station would disturb approximately 1.25 acres. Both the village business center and Maswik construction sites are presently disturbed areas.

The double-track light rail corridor running from the Mather Point center to Maswik would be 2.67 miles long and disturb approximately 69 acres. Therefore, the area affected by construction in this alternative would be about 70.75 acres, most of which would be in piñon/juniper habitat, although some Ponderosa pine habitat would be affected. The total amount of area affected by this alternative, including the 20.7 acres affected by "Impacts Common to All Action Alternatives", would be approximately 91.45 acres.

Conclusion. In addition to the 20.7 acres affected by developments in "Impacts Common to All Action Alternatives", 70.75 acres of piñon/juniper woodland and some Ponderosa pine habitat would be disturbed by construction in this alternative. Thus, the total amount of area affected by implementation of alternative 2 would be approximately 91.45 acres.

Air Quality

Analysis. Same as alternative 1.

Conclusion. Same as alternative 1.

Noise

Analysis. Impacts would be the same as described in "Impacts Common to All Action Alternatives." Additionally, sounds generated by the light rail as it traveled through the village relatively close to the rim would be heard by visitors in the village and rim areas. Audible light rail traffic warning alarms would sound at the two at-grade crossings; such alarms would also be heard by village visitors. For the year 2010 summer season, a fleet of 10 shuttle buses with an average headway of 4 minutes would be required. However, when viewed in context of the existing sounds of automobiles, tour buses, the Grand Canyon Railway train, and the railroad tracks' audible at-grade traffic warning alarms that are currently a common and accepted noise experience in the village, noise levels and frequencies would be less.

Conclusion. Impacts would be the same as described in "Impacts Common to All Action Alternatives." Additionally, sounds of the light rail as it traveled through the village and the alarms of the two at-grade light rail crossings would be heard by visitors in the village and rim areas. However, when viewed in context of the existing sounds of the village noise levels and frequencies would be less.

Cultural Resources

Analysis. Impacts would be the same as described in "Impacts Common to All Action Alternatives." In addition, construction of a dedicated light rail corridor from Tusayan to the Mather Point orientation and transit center could disturb at least 18 archeological sites. As many as 12 more sites could be disturbed by construction of a dedicated light rail corridor paralleling South Entrance Road from Mather Point west to the Maswik transportation center.

Routing of the light rail corridor from the Mather orientation and transit center through Grand Canyon Village Historic District to the Maswik transportation center would intrude on the historic scene. Additionally, a 9- to 12-foot section of a historic stone wall would be breached and rails at the southernmost part of the railyard would be removed and reused in design of light rail.

Conclusion. In addition to those impacts that are common to all action alternatives, the proposed routing of light rail would intrude on the scene of the Grand Canyon Village Historic District, and a section of the historic stone wall would be lost. A total of 30 sites could be disturbed by the construction of a dedicated transportation corridor. It is anticipated that any impacts on archeological sites would be avoided through design or mitigation. However, impacts on the Grand Canyon Village Historic District would likely be adverse.

Visitor Experience

Analysis. Impacts would the similar to alternative 1, except that visitors would have direct light rail access to the village area and would not be required to transfer to a shuttle bus. In the year 2000 there would be a light rail transportation cost of $2.82 for each visitor; this fee would drop to $2.41 in the year 2010. In the year 2000 there would be a South Rim shuttle bus cost of $.44 for each visitor; this fee would drop to $.43 in the year 2010.

Conclusion. Impacts would be similar to alternative 1, except that visitors would have direct light rail access to the village area and would not be required to use the shuttle buses. The light rail transportation cost for each visitor in the year 2000 would decrease by the year 2010, and the South Rim shuttle bus cost for each visitor in 2000 would decrease by 2010.

Scenic Values

Analysis. Same as alternative 1.

Conclusion. Same as alternative 1.

Traffic Management

Analysis. Impacts would be the same as described in “Impacts Common to All Action Alternatives.” Additionally, the tracks used for the light rail service would cross the access road to the existing dry dump maintenance area and Center Road. Traffic management for these two crossings would be controlled with grade-separating concrete bridges at both of these locations to enable road traffic to cross over the main line tracks of the light rail system.

The light rail would also be sharing the transportation route with the village loop road, and would require traffic crossings at Center Road, the new campground access road, and at a number of locations within the village. Such crossings would be constructed according to all safety codes. Additionally, in order to maintain separation of light rail and wheeled vehicles, individual transportation corridors would be identified within the transportation route. To enhance traffic management and safety, the individual transportation corridors would be physically separated and, possibly, landscaping would be developed between them.

Conclusion. In addition to those impacts that are common to all action alternatives, impacts on traffic management resulting from alternative 2 would be minor.

Park/Transit Operations

Analysis: Impacts would be the same as described in "Impacts Common to All Action Alternatives." Additionally, approximately 60 people would be needed to operate the light rail system during the summer peak season of the 2010 and a total of 24 light rail cars (20 operational + 4 spares) would be needed for operation of the system. For the year 2010, the estimated total annual costs, including capital and operations and maintenance, for the light rail system would be $16.5 million. Approximately 35 people would be needed to operate the shuttle bus system during the summer peak season of the year 2010 and a total of 13 (10 active + 3 spares) buses would be needed for operation of the system. For the year 2010, the estimated total annual costs, including operations and maintenance, capital, and rolling stock fee, for the shuttle bus system would be $2.1 million.

Conclusion. Long-term impacts on park operations would be beneficial. Implementation of light rail would provide a single system of traffic movement to and from the South Rim.

IMPACTS OF ALTERNATIVE 3

Please refer to appendix C for the methodologies related to the development of a visitor transit system under alternative 3.

Biotic Communities

Analysis. Impacts would be the same as described in "Impacts Common to All Action Alternatives." Additionally, construction of the village business center light rail station would disturb approximately 0.5 acre, and remodeling of the Maswik light rail station would disturb approximately 1.25 acres. Both the village business center and Maswik construction sites are currently disturbed areas.

The single-track light rail corridor running from near the intersection of Center Road and South Entrance Road, to the Mather Point center, through the village business center and Maswik, and on to connect back with the light rail corridor near the intersection of Center and South Entrance Roads would be 6.6 miles long and disturb approximately 44.25 acres. The double-track light rail corridor from the southern park boundary to the Center Road and South Entrance Road junction would be 4.5 miles long and would disturb approximately 32.6 acres. Therefore, the area affected by construction in this alternative would be about 78.6 acres, most of which would occur in piñon/juniper habitat, although some Ponderosa pine habitat would be affected. The total amount of area affected by alternative 3, including the 20.7 acres affected by developments common to all action alternatives, would be approximately 99.3 acres.

Conclusion. In addition to the 20.7 acres affected by those developments that are common to all action alternatives, 78.6 acres of piñon/juniper woodland and some Ponderosa pine habitat would be disturbed by construction in this alternative. Thus, the total amount of area affected by implementation of alternative 3 would be approximately 99.3 acres.

Air Quality

Analysis. Same as alternative 1.

Conclusion. Same as alternative 1.

Noise

Analysis. Same as alternative 2.

Conclusion. Same as alternative 2.

Cultural Resources

Analysis. Impacts would be the same as described in “Impacts Common to All Action Alternatives." In addition, at least 18 known archeological sites could be disturbed by construction of a light rail corridor from Tusayan to the Mather Point orientation and transit center. Continuation of a corridor from Mather Point to the Maswik transportation center could disturb 12 more archeological sites, and a west loop from Maswik to Center Road could affect 7 known sites.

The proposed routing of the light rail corridor from the Mather orientation and transit center to the Maswik transportation center would intrude on the historic scene of Grand Canyon Village Historic District. Additionally, a 9- to 12-foot section of a historic stone wall would be breached, and rails at the southernmost part of the railyard would be removed and reused in the design of light rail.

Conclusion. In addition to those impacts that are common to all action alternatives, as many as 37 archeological sites could be disturbed by construction of a dedicated transportation corridor. Routing of the light rail corridor would have impact on Grand Canyon Village Historic District. It is anticipated that any impact on archeological sites would be avoided through design or mitigated. However, impacts on the Grand Canyon Village Historic District would likely be adverse.

Visitor Experience

Analysis. Impacts would similar to alternative 1, except that visitors would have direct light rail access to the village area and would not be required to transfer to a shuttle bus. In the year 2000 there would be a light rail transportation cost of $2.70 for each visitor; this fee would drop to $2.28 in the year 2010. In the year 2000 there would be a South Rim shuttle bus cost of $.44 for each visitor; this fee would drop to $.43 in the year 2010.

Conclusion. Impacts would be similar to alternative 1, except that visitors would have direct light rail access to the village area and would not be required to use the shuttle buses. The light rail transportation cost for each visitor in 2000 would decrease in 2010, and the South Rim shuttle bus cost for each visitor in 2000 would decrease in 2010.

Scenic Values

Analysis. Same as alternative 1.

Conclusion. Same as alternative 1.

Traffic Management

Analysis. Same as alternative 2

Conclusion. Same as alternative 2.

Park/Transit Operations

Analysis. Impacts would be the same as described in “Impacts Common to All Action Alternatives.” Additionally, approximately 54 people would be needed to operate the light rail system during the summer peak season of the 2010 and a total of 22 light rail cars (18 operational + 4 spares) would be needed for operation of the system. For the year 2010, the estimated total annual costs, including capital and operations and maintenance, for the light rail system would be $15.6 million. Approximately 35 people would be needed to operate the shuttle bus system during the summer peak season of the year 2010 and a total of 13 (10 active + 3 spares) buses would be needed for operation of the system. For the year 2010, the estimated total annual costs, including operations and maintenance, capital, and rolling stock fee, for the shuttle bus system would be $2.1 million.

Conclusion. Long-term impacts on park operations would be beneficial. Implementation of light rail would provide a single system of traffic movement to and from the South Rim.

IMPACTS OF PROPOSED ACTION

Please refer to appendix D for the methodologies related to the development of a visitor transit system under the proposed action.

Biotic Communities

Analysis. Impacts would be the same as described in “Impacts Common to All Action Alternatives.” In addition, remodeling of the Maswik light rail station would disturb approximately 1.25 acres. The Maswik construction site is a previously disturbed area.

The double-track light rail corridor would be approximately 8.95 miles long and disturb approximately 75 acres. Therefore, the area affected by proposed construction would be about 75 acres, most of which would be in piñon/juniper habitat, although some Ponderosa pine habitat would be affected. The total amount of area affected by the proposed action, including the 20.7 acres affected by proposed developments common to all action alternatives, would be approximately 95.7 acres.

Conclusion. In addition to the 20.7 acres affected by those developments that are common to all action alternatives, 75 acres of piñon/juniper woodland and some Ponderosa pine habitat would be disturbed by construction proposals in this alternative. Thus, the total amount of area affected by implementation of the proposed action would be approximately 95.7 acres.

Air Quality

Analysis. Same as alternative 1.

Conclusion. Same as alternative 1.

Noise

Analysis. Impacts would be the same as alternative 1. However, for the year 2010 summer season a fleet of 15 shuttle buses would be required. This is slightly less than half the number of shuttle buses required for alternative 1, with a corresponding decrease of shuttle bus noise levels.

Conclusion. Impacts would be the same as alternative 1. However, for the year 2010 summer season a fleet of 15 shuttle buses would be required. This is slightly less than half the number of shuttle buses required for alternative 1.

Cultural Resources

Analysis. Impacts would be the same as described in "Impacts Common to All Action Alternatives." In addition, at least 18 archeological sites could be disturbed by construction of a dedicated light rail corridor from Tusayan and the Mather Point orientation and transit center, and seven more sites could be disturbed by construction of a dedicated light rail corridor west from the intersection of South Rim Drive and Center Road to the Maswik transportation center. Revegetation of approximately 1 mile of South Rim Drive northwest from the Mather orientation and transit center could result in the disturbance of seven sites.

The routing of the light rail corridor along Center Road would not intrude on the historic scene of Grand Canyon Village Historic District.

Conclusion. In addition to those impacts that are common to all action alternatives, at least 32 archeological sites could be disturbed. Through avoidance in design or mitigation, the effects would not be adverse.

Visitor Experience

Analysis. Impacts would be similar to alternative 1, except that visitors would have direct light rail access to the village area and would not be required to transfer to shuttle buses. In the year 2000 there would be a light rail transportation cost of $2.23 for each visitor; this fee would drop to $1.88 in the year 2010. In the year 2000 there would be a South Rim shuttle bus cost of $.67 for each visitor; this fee would drop to $.61 in the year 2010.

Conclusion. Impacts would be similar to alternative 1, except that visitors would have direct light rail access to the village area and would not have to use the shuttle buses. However, the light rail transportation cost for each visitor in 2000 would decrease in the year 2010, and the South Rim shuttle bus cost for each visitor in 2000 would decrease in 2010.

Scenic Values

Analysis. Impacts would be the same as described in "Impacts Common to All Action Alternatives." Additionally, although the light rail corridor would not run through the village area, the light rail corridor, and the frequently run light rail itself, up to Mather Point and Maswik may be perceived as a visual intrusion. For much of its length, however, the corridor would be screened by tall trees and dense forest and impacts on scenic values are not expected to be appreciable.

Conclusion. Impacts would be the same as described in "Impacts Common to All Action Alternatives." Additionally, for much of its length the light rail corridor would be screened by tall trees and dense forest and impacts on scenic values are not expected to be appreciable.

Traffic Management

Analysis. Same as alternative 1.

Conclusion. Same as alternative 1.

Park/Transit Operations

Analysis. Impacts would be the same as described in "Impacts Common to All Action Alternatives." Additionally, approximately 42 people would be needed to operate the light rail system during the summer peak season of the 2010 and a total of 17 light rail cars (14 operational + 3 spares) would be needed for operation of the system. For the year 2010, the estimated total annual costs, including capital and operations and maintenance, for the light rail system would be $12.9 million. Approximately 53 people would be needed to operate the shuttle bus system during the summer peak season of the year 2010 and a total of 19 buses (15 active + 4 spares) buses would be needed for operation of the system. For the year 2010, the estimated total annual costs, including operations and maintenance, capital and rolling stock fee, would be $3.2 million.

Conclusion. Long-term impacts on park operations would be beneficial. Implementation of light rail would provide a single system of traffic movement to and from the South Rim.

CUMULATIVE IMPACTS

The cumulative impacts of this project would be the same as described in the draft environmental assessment.

APPENDIX A

Design Parameters - Alternative 1
Visitor Transit System
Grand Canyon National Park, Arizona

This document is intended to provide the members of the Grand Canyon GMP Implementation Team with updated information about the design parameters related to the development of Alternative 1 for a visitor transit system within the Park. Alternative 1 includes a light rail passenger service operating between a parking area to be located outside of the Park near the north end of Tusayan and a new Visitor Orientation Center at Mather Point. A fleet of buses operating on several fixed routes will be used to provide visitor circulation within the Village. Both the light rail and the bus service will operate year-round.

All visitors to the Village would be required to park at the lot in Tusayan and ride the light rail system to access Mather Point, then ride the bus system to the Village, and the West Rim. Overnight guest vehicles will be allowed on specific Park roads for the sole purpose of accessing their designated lodge parking area or campground. Tour buses will not be allowed access to Mather Point or the Village. Tour bus passengers will have use the light rail system and the bus system in order to visit Mather Point and all points to the west.

1. Visitor and Vehicle Projections

1.1 Design Day Calculations

<u>Assumptions used in Design Day calculations:</u>

1994 Total Visitation = 4,172,814	1994 South Rim Visitation = 3,751,014
2000 Total Visitation = 5,182,384	2000 South Rim Visitation = 4,722,259
2010 Total Visitation = 6,865,000	2010 South Rim Visitation = 6,341,000

<u>Modal Split</u>

For the purposes of this analysis the mode splits for the year 2000 are estimated to be 75% by car, 8.4% by shuttle Bus, 13.6% by tour bus, and 3% by train. In the 2010 design year the modal splits are 72.7% by car, 9.3% by shuttle bus, 15% by tour bus and 3% by GCRR train.

<u>YEAR 2000 - South Rim</u>

<u>Summer Design Day 2000 = 37,554 visitors</u>

75% private veh. = 28,166 vis. by private veh./ 3.3 PPV = 8,535 veh. (8,180 cars & 355 RV's)
8.4%shuttle bus = 3,155 vis. by shuttle bus/ 31 PPV = 102 shuttle buses
13.6% tour bus = 5,107 vis. by tour bus/ 3 1 PPV = 165 tour buses
3% train = 1,127 vis. by train

<u>Winter Design Day 2000 = 12,855 visitors</u>

75% private veh. = 9,641 vis. by private veh./ 2.6 PPV = 3,708 veh. (3,542 cars & 166 RV's)
8.4%shuttle bus = 1,080 vis. by shuttle bus/ 31 PPV = 35 shuttle buses
13.6% tour bus = 1,748 vis. by tour bus/ 31 PPV = 56 tour buses
3% train = 386 vis. by train

YEAR 2010 - South Rim

Summer Design Day 2010 = 45,000 visitors
72.7% private veh. = 32,715 vis. by private veh./ 3.3 PPV = 9,914 veh. (9,502 cars & 412 RV's)
9.3% shuttle bus = 4,185 vis. by shuttle bus/ 31 PPV = 135 shuttle buses
15% tour bus = 6,750 vis. by tour bus/ 31 PPV = 218 tour buses
3% train = 1,350 vis. by train

Winter Design Day 2010 = 15,404 visitors
72.7% private veh. = 11,199 vis. by private veh./ 2.6 PPV = 4,307 veh. (4,130 cars & 177 RV's)
9.3% shuttle bus = 1,433 vis. by shuttle bus/ 31 PPV = 46 shuttle buses
15% tour bus = 2,311 vis. by tour bus/ 31 PPV = 75 tour buses
3% train = 462 vis. by train

2. Parking Requirements

Tusayan Parking Area

The parking area at Tusayan should be sized to accommodate the peak summer demand in 2010. The vehicle projections presented in the first section of this memo, an 80/20 split between the Village and the East Rim, and a 40% accumulation rate were used to estimate the parking requirements at the Tusayan site. It is estimated that the parking area should be sized to handle approximately 3,041 cars, 132 RV's, and 70 buses. Using 300 sf per car and 1,000 sf per bus and RV, the parking area would have a 25.6 acre paved surface.

3. Light Rail System Requirements

3.1 Light Rail Operation

The light rail portion of the transit system will operate between Tusayan and Mather Point. The roadbed for the light rail system will be located in a dedicated right-of-way. A double track roadbed will be used for the entire system. The main line of the light rail system will be located to the west of and parallel to the South Entrance Road between Tusayan and Mather Point.

The tracks used for the light rail service will cross the Park road system at two locations. The main line will cross the access road to the existing "Dry Dump" maintenance area and Center Road. A concrete bridge structure will be used at both of these locations to enable road traffic to cross over the main line tracks of the light rail system.

The light rail system will operate seven days a week year-round. During the summer season (June - August) light rail service with maximum vehicle headways of about five minutes will be available between the hours of 6 AM and 10 PM. Between the hours of 10 PM and 6 AM light rail service will be provided by a single vehicle operating on a one hour frequency. A separate on-demand dial-a-ride taxi service will also be available for a fee from the concessionaire between 10 PM and 6 AM.

During the shoulder seasons (September-November and March-May) the light rail service will operate between the hours of 7 AM and 9 PM. Maximum vehicle headways of 10 minutes will be maintained during the day the same as during the summer season. Evening light rail service between the hours of 9 PM and 7 AM will be similar to the summer night operation with hourly service.

During the winter season (December- February) the light rail service will be available between the hours of 7 AM and 8 PM. Maximum vehicle headways of 15 minutes will be maintained during the day. Evening light rail service between the hours of 8 PM and 7 AM will be similar to the summer night operation with hourly service.

The round-trip route is approximately 12.35 miles in length and the average operating speed of the vehicles is 45 MPH. Stops for loading and unloading will only occur at the two terminals and are estimated to take three minutes per stop. The estimated round-trip travel time is estimated to be 23 minutes including the stops. During peak periods during the summer and shoulder seasons the light rail vehicles will be connected together to form two-car trains. Each light rail vehicle will carry 175 passengers (seated plus standing) and provide a total of 455 rides per vehicle per hour (910 per 2 car-train).

The transit system is sized to accommodate the peak hourly load. A peak hour factor of 13% of the daily demand was used. The 80% distribution factor was used the same as in the parking calculation. A total of 495 overnight guests (150 vehicles x 3.3 PPV) were subtracted from the peak hour summer transit demand. A total of 390 overnight guests (150 vehicles x 2.6 PPV) were subtracted from the peak hour transit demand during the shoulder and winter seasons.

Note that the shoulder season demand was estimated to be 70% of the summer demand value.

<u>2000 Summer Light Rail Demand</u>
Summer Design Day = 28,166 by car + 5,107 by tour bus = 33,273 visitors
Max. Transit demand = [(((33,273 x 80%) + 3,155 by shuttle bus) x 13%) - 495] = 3,376 rides/hr
Route Requirements = 3,376/455 = 8 light rail vehicles (4 two-car train units)
Vehicle Headway = 23/4 = 5.75 minutes
Fleet Requirements = 8 vehicles + 2 spares = **10 light rail vehicles**

<u>2000 Shoulder Light Rail Demand</u>
Shoulder Design Day = 19,716 by car + 3,575 by tour bus = 23,291 visitors
Max. Transit demand = [(((23,291 x 80%) + 2,209 by shuttle bus) x 13%) - 390] = 2,319 rides/hr
Route Requirements = 2,319/455 = 6 light rail vehicles (3 two-car trains)
Vehicle Headway = 23/3 = 7.66 minutes
Fleet Requirements = 6 vehicles + 2 spares = **8 light rail vehicles**

<u>2000 Winter Light Rail Demand</u>
Winter Design Day = 9,641 by car + 1,748 by tour bus = 11,389 visitors
Max. Transit demand = [(((11,389 x 80%) + 1,080 by shuttle) x 13%) -390] = 935 rides/hr
Route Requirements = 935/455 = 3 light rail vehicles
Vehicle Headway = 23/3 = 7.66 minutes
Fleet Requirements = 3 vehicles + 2 spares = **5 light rail vehicles**

<u>2010 Summer Light Rail Demand</u>
Summer Design Day = 32,715 by car + 6,750 by tour bus = 39,465 visitors
Max. Transit demand = [(((39,465 x 80%) + 4,185 by shuttle) x 13%) - 495] = 4,153 rides/hr
Route Requirements = 4,153/455 = 10 light rail vehicles (5 two-car train units)
Vehicle Headway = 23/5 = 4.6 minutes
Fleet Requirements = 10 vehicles + 3 spares = **13 light rail vehicles**

<u>**2010 Shoulder Light Rail Demand**</u>
Shoulder Design Day =22,901 by car + 4,725 by tour bus = 27,626 visitors
Max. Transit demand = [(((27,626 x 80%) + 2,930 by shuttle) x 13%) - 390] = 2,864 rides/hr
Route Requirements = 2,864/455 = 8 light rail vehicles (4 two-car trains)
Vehicle Headway = 23/4 = 5.75 minutes
Fleet Requirements = 8 vehicles + 2 spares = **10 light rail vehicles**

<u>**2010 Winter Light Rail Demand**</u>
Winter Design Day = 11,199 by car + 2,311 by tour bus = 13,510 visitors
Max. Transit demand = [(((13,510 x 80%) + 1,433 by shuttle) x 13%) -390] = 1,201 rides/hr
Route Requirements = 1,201/455 = 3 light rail vehicles
Vehicle Headway = 23/3 = 7.66 minutes
Fleet Requirements = 3 vehicles + 2 spares = **5 light rail vehicles**

Table 1 summarizes the light rail requirements for each season for the years 2000 and 2010.

TABLE 1: Light Rail System Requirements

Year/Season	Demand	Light Rail Vehicles Required(Route requirements plus spares)	Headway
2000 Summer	3,376 Rides/hr.	8 + 2 = 10	5.75 minutes
2000 Shoulder	2,319 Rides/hr.	6 + 2 = 8	7.66 minutes
2000 Winter	935 Rides/hr.	3 + 2 = 5	7.66 minutes
2010 Summer	4,153 Rides/hr.	10 + 3 = 13	4.6 minutes
2010 Shoulder	2,864 Rides/hr.	8 + 2 = 10	5.75 minutes
2010 Winter	1,201 Rides/hr.	3 + 2 = 5	7.66 minutes

3.2 Light Rail System Personnel Requirements

The personnel requirements have been estimated based on a rate of 3 employees per active light rail vehicle in operation during peak periods (with a minimum of 12 employees). This estimate covers drivers, mechanics, and administrative personnel. The personnel estimates presented in Table 2 are based on the seasonal requirements in the years 2000 and 2010.

TABLE 2: Light Rail Personnel Requirements

Year/Season	Maximum Active Trains	Personnel Required
2000 Summer	8	24
2000 Shoulder	6	18
2000 Winter	3	12
2010 Summer	10	30
2010 Shoulder	8	24
2010 Winter	3	12

3.3 Light Rail System Capital Cost

The full-build (year 2010) light rail system capital cost was estimated to be cost $49.4 million in 1997 dollars. A subsystem breakdown of this cost is provided in Table 3.

Recent light rail system costs were reviewed from FTA aggregate data as well as specific detailed cost data from L.A. LRT Blue Line, St. Louis LRT and San Francisco BART (RRT) projects. The high level of detail in this cost data allowed both bottom-up and top-down cost estimating approaches to be used. Data was adjusted for grade (at-grade), time (1997) and location. Costs were adjusted for location using the Engineering News Record's cost index for 22 U.S. cities, including Los Angeles, St. Louis and San Francisco. For some items an additional bottom-up approach using the 1997 RS Means Heavy Construction Cost Data was employed.

TABLE 3: Light Rail System - Capital Cost Summary

Subsystem	Unit	Quantity	Unit Cost	Total Cost
DMU Vehicles	vehicles	13	$1,350,000	$17,550,000
Sub Grade & Track	dual-lane miles	6.18	$1,860,000	$11,494,800
Excavation	cubic yards	179,840	$8.32	$1,496,269
Embankment	cubic yards	190,136	$7.48	$1,422,217
Train Control	dual-lane miles	1.5	$1,960,000	$2,940,000
Stations	stations	2	$815,000	$1,630,000
Maintenance Facility	vehicles	13	$220,000	$2,860,000
Grade Separation at Center Road	---	---	---	$776,390
Grade Separation at Maintenance Road	---	---	---	$990,134
Engineering / Proj. Mgmt.	percent	20%	---	$8,231,962
Total Costs				**$49,391,772**

It is unclear whose jurisdiction this project would fall under; the Federal Transit Administration (FTA), the Federal Railroad Administration (FRA), or possibly a State of Arizona body. Hazards analysis, quality control, quality assurance, schedule adherence, interface coordination and third-party oversight are all mechanisms which can provide the Park Service the proper level of comfort required to undertake this project. The level of detail to which these items can be taken can vary widely. These items are accounted for in the engineering and project management component of the cost estimate.

<u>Light Rail - Rolling Stock</u>

A total of seventeen vehicles is specified for the year 2010 with fourteen operating in the peak period and three spares. This spare ratio is considered adequate. Recent light rail vehicle costs were reviewed and adjusted for time, location and power source. The ABB/ADtranz RegioShuttle and the Bombardier Target add the potential for direct vehicle supplier competition which will keep the vehicle cost down. Assuming supplier competition, a recommended budgetary cost for DMU rail vehicles is $1.35 million per vehicle or $17.55 million for the entire fleet.

Light Rail Track, Switches and Train Control

The light rail system in this alternative consists of approximately 6.18 miles of dual lane track. Ballast and sub ballast quantities were estimated for a fully loaded RegioSprinter. Other components included clear&grub, grading, embankment, underdrain, service road aisle and ballasted track procurement and installation. Given the quantities determined above, sub-grade and track has a unit cost of $1,860,000 per dual-lane mile for a total cost of $11.5 million. The unit cost was estimated from both a top-down method and a bottom-up method. The top-down method incorporated total trackwork costs from FTA data (average and low), L.A. Blue Line and St. Louis LRT projects. The bottom-up method used 1997 Means Construction costs for 90 and 115 pound Relay Rail, ties, ballast, sub ballast, installation (crew) and alignment.

Components within excavation include hauling of materials, drilling and blasting, backfill and grading. Components within embankment include hauling of materials, backfill and grading. From the quantities provided, it was estimated the alignment would have approximately 180,000 cubic yards of excavation and 190,000 cubic yards of embankment. Excavation and embankment had unit costs of $8.32 and $7.48 per cubic yard respectively. Total excavation costs were $1.5 million and total embankment costs were $1.4 million. Unit costs were estimated from both a top-down method and a bottom-up method. The top-down method incorporated total trackwork costs from FTA data (average and low), L.A. Blue Line and St. Louis LRT projects. The bottom-up method used 1997 Means cost data.

It was assumed that train control or signalization would be implemented at the two stations, along the steepest grade (3.5 and 4.0 percent) trackwork, crossovers, turnouts and road crossings. This resulted in approximately 25 percent or 1.5 dual-lane miles of the alignment having signalization. The alignment has two terminating stations (end-of-line stations) which require signalization due to the train's turnback operations. The signal system and its associated cost can range from simple vehicle detection systems for grade crossing protection to fully automated systems that require little or no train operator actions. For this alignment it is assumed that a fixed block-type train control system using wayside signal lights would be used with provisions for interlocking. Train control had a unit cost of $1.96 million per dual-lane mile which was estimated from both a top-down method and a bottom-up method. The total train control cost was $2.9 million.

Roadway/Light Rail Grade-Separated Crossings

Two grade-separated crossings will be required. One crossing will be with Center Road, where the light rail will pass under the road in the existing drainage channel. The other crossing will be where the light rail will pass under the maintenance road that leads to the maintenance area. In both cases the roadway will need to be elevated and new concrete bridge spans installed. The cost estimates are shown below:

Crossing #1: Center Road & Light Rail

Approach Fill Req'd: 9,500 cubic meters (@ $9.00 per c.m.)= $85,000.00
Roadway Removal Req'd: 2,160 square meters (@ $6.00 per sq. m.)= $12,960.00
New Roadway Req'd: 29,527 square feet (@ $6.00 per sq. ft.)= $177,162.00
Total Bridge Cost: $400,000.00 (@ 80.00 per sq. ft.)

Subtotal Const.	= $675,122
15% Contingency	= $101,2680
TOTAL COST	**= $776,390**

Crossing #2: Maintenance Access Road & Light Rail

Approach Fill Req'd: 22,350 cubic meters (@ $9.00 per c.m.)= $201,150.00
Roadway Removal Req'd: 2,952 square meters (@ $6.00 per sq. m.)= $17,712.00
New Roadway Req'd: 40,354 square feet (@ $6.00 per sq. ft.)= $242,124.00
Total Bridge Cost: $400,000.00 (@ $80.00 per sq. ft.)

Subtotal Const.	= $860,986
15% Contingency	= $129,148
TOTAL COST	**= $990,134**

Light Rail Stations

The alignment has two stations (Tusayan and Mather Point), both of which would be at-grade, terminating (end-of-line) stations. Recent light rail at-grade station costs were reviewed and adjusted for time, location and assumed number of platforms per station. The resulting cost of typical side-center-side platform at-grade light rail station is $815,000 for a total station cost of $1.63 million. It is assumed the Park Service would pay for all station costs.

Light Rail Maintenance Facility

The maintenance facility cost was estimated using unit costs from recent constructed light rail system maintenance facilities, adjusted for time and location. Adjusted light rail maintenance facility costs were found to be approximately $220,000 per vehicle. The total cost of the facility was estimated to be $2.86 million.

Light Rail Engineering/Project Management

Typically on FTA funded light rail transit projects, these are 25 to 30 percent of the total construction costs. These projects fall under the jurisdiction of the FTA, whose regulations are relatively extensive. With it unclear whose jurisdiction this project would fall under, it is recommended that an engineering and project management estimate of 20 percent of the total construction costs be used for a total cost of $8.2 million. This reduced percentage assumes less onerous regulations and compliance than on FTA work.

3.4 Light Rail Operation and Maintenance Costs

For the year 2000, total operations and maintenance costs were estimated to be approximately $2.66 million. From an operations analysis, a total of 27,437 hours were calculated. A cost of $96.90 per vehicle revenue hour was used. FTA data for light rail operating costs per vehicle revenue hour has a low of $36.90 and an average of $153.73.

For the year 2010, total operations and maintenance costs were estimated to be $3.81 million. From the operations analysis, a total of 34,644 hours were determined. A cost of $110.00 per vehicle revenue hour was used for the 2010 O&M estimate.

3.5 Light Rail - Cost per Visitor

The cost per visitor for the light rail system is identified in the Table 4 below:

TABLE 4: Light Rail Cost Per Visitor

	Year 2000	Year 2010
Annual Capital Cost*	$5,770,441	$5,770,441
Annual O & M Cost	$2,658,645	$3,810,807
Total Annual Cost	$8,429,086	$9,581,218
Visitation	5,182,384	6,865,000
Cost per Visitor	**$1.63**	**$1.40**

*$49,391,772 x .11683 =$5,770,441/yr based on 8% for 15 yrs

4. Bus System Requirements

4.1 Bus System Operation

A fleet of buses will provide for the visitor transportation needs in those areas of the village that are not served directly by the light rail system. The bus fleet will likely consist of 50 passenger LNG buses and 25 passenger battery powered buses. The electric buses are planned for use on the route serving Yavapai Observation Point, while the LNG buses are planned for all of the other routes included in this alternative. All of the buses in the fleet will be designed to have a low floor (14 inches or less) with wide doors opening on the right side of the vehicle.

The bus system will operate seven days a week year-round. bus service will be available between the hours of 6 AM and 10 PM during the summer, 7 AM and 9 PM during the shoulder season, and 7 AM and 8 PM during the winter. Vehicle headways will vary depending on the route and season. In most cases the headways will always be 20 minutes or less. A separate on-demand dial-a-ride taxi service will be available for a fee from the concessionaire during the night after the bus service has ended.

In addition to the bus service that is common to all alternatives (West Rim, Yaki Point) this alternative includes additional buses operating on four other fixed routes. These routes include Mather - Yavapai Museum, Mather - Village, Business Center Loop, and Village Loop. These routes are described below:

Mather-Yavapai Museum Route - 3.0 mile round trip route (25 MPH avg. speed)
2 stops (2 min/stop) - Mather Point and Yavapai Museum
12 minute round trip travel time.

Demand Assumption:

The bus service will be used to regulate the visitor flow to the museum. Anticipated demand will be greatly influenced by the specific loading location at Mather, the frequency of the buses and the amount of marketing performed. It is likely that this demand could increase significantly if the route were highly advertised. Actual demand is unknown. For the purposes of this analysis it is assumed that demand for this bus service will be 10% of the light rail demand. It is assumed that 25 passenger, battery powered buses will be used on this route. The service requirements of this route are shown in Table 5.

TABLE 5: Mather - Yavapai Museum Bus Route

Year/Season	Estimated Demand	Buses Required	Headway	Transit Supply
2000 Summer	338 rides/hr	3 - 25 passenger buses	4 minutes	375 rides/hr
2000 Shoulder	232 rides/hr	2 - 25 passenger buses	6 minutes	250 rides/hr
2000 Winter	94 rides/hr	1 - 25 passenger bus	12 minutes	125 rides/hr
2010 Summer	415 rides/hr	4 - 25 passenger buses	3 minutes	500 rides/hr
2010 Shoulder	286 rides/hr	3 - 25 passenger buses	4 minutes	375 rides/hr
2010 Winter	120 rides/hr	1 - 25 passenger bus	12 minutes	125 rides/hr

Mather - Village Route - 4.5 mile round trip route (25 MPH avg. speed)
3 stops (2 min/stop)- Maswik T.C., Business Center, and Mather Point
17 minute round trip travel time

Demand Assumption:

The ridership demand for the Mather - Village Route is assumed to be 90% of the light rail demand. The service requirements for this route are shown in Table 6.

TABLE 6: Mather - Village Bus Route

Year/Season	Estimated Demand	Buses Required	Headway	Transit Supply
2000 Summer	3,038 rides/hr	18 - 50 passenger buses	1 minute	3,150 rides/hr
2000 Shoulder	2,087 rides/hr	12 - 50 passenger buses	1.4 minutes	2,100 rides/hr
2000 Winter	842 rides/hr	5 - 50 passenger buses	3.4 minutes	875 rides/hr
2010 Summer	3,738 rides/hr	22 - 50 passenger buses	4 minutes	3,850 rides/hr
2010 Shoulder	2,578 rides/hr	15 - 50 passenger buses	4 minutes	2,625 rides/hr
2010 Winter	1,081 rides/hr	7 - 50 passenger buses	12 minutes	1,225 rides/hr

Business Center Loop Bus Route - 2.2 mile round trip route (20 MPH avg. speed)
5 stops (1 min/stop)- Business Center, Yavapai Lodge,
Yavapai East, Campground, and RV Park
12 minute round trip travel time

Demand Assumption:

This route will primarily serve overnight guests wishing to circulate in the developments in the vicinity of the Business Center. The number of day visitors that will use this bus route is believed to be relatively small. This route also serves as the only bus access to the Yavapai Lodge, the campground, and RV park. These overnight accommodations represent about 800 guest units serving approximately 2,640 overnight guests during the summer months. Many of these overnight guests will ride this bus to access their lodge or camping area. The overnight guests will likely use this bus to circulate throughout the business area and will transfer to the Mather -Village Bus Route to access the other areas of the Village.

The number of guests staying in the campground, RV park, and the Yavapai Lodge will remain constant over time. It is estimated that during the peak hour of the day during the summer the overnight guests staying at the facilities in the vicinity of the Business Center will generate a ridership demand of 343 rides/hr (based on a 13% peak hour factor). It was estimated that the overnight guests would generate 240 rides/hr (70% of summer) for the shoulder season and 86 rides/hr (25% of summer) for the winter season. Table 7 shows the service requirements of this route.

TABLE 7: Business Center Loop Bus Route

Year/Season	Estimated Demand	Buses Required	Headway	Transit Supply
2000 Summer	343 rides/hr	2 - 50 passenger buses	6 minutes	500 rides/hr
2000 Shoulder	240 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr
2000 Winter	86 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr
2010 Summer	343 rides/hr	2 - 50 passenger buses	6 minutes	500 rides/hr
2010 Shoulder	240 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr
2010 Winter	86 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr

Village Loop Bus Route - 1.75 mile route (20 MPH avg. speed)
6 stops - (1 min/stop) El Tovar, Bright Angle, West Rim Interchange, Maswik Lodge, Maswik T.C., and Heritage Campus
12 minute round trip travel time
Summer 2010 demand = 25% of rail demand = 1,038 rides/hr

Demand Assumptions:

This bus route will circulate throughout the Village with a stop at the Light Rail station. The current bus service on the Village Loop provides the equivalent of about 500 rides per hour (over the length of the entire route). Without their vehicles the visitor is expected to rely more on this route for moving about the Village. It is estimated that the demand for this bus service will be 20% of the light rail demand. For the purposes of this analysis it is assumed that 25 passenger battery powered buses would be used on the Village Loop Bus Route. The service requirements of the Village Loop Bus Route are shown in Table 8.

Note that during the winter season it may be desirable to use two 25 passenger battery powered buses for the Village Loop instead of the single 50 passenger vehicle that is used on this route during the rest of the year. The use of two of the smaller buses on this route during the winter months would produce a more desirable headway of 6 minutes versus the 12 minute headway shown in Table 8.

TABLE 8: Village Loop Bus Route

Year/Season	Estimated Demand	Buses Required	Headway	Transit Supply
2000 Summer	675 rides/hr	3 - 50 passenger bus	4 minutes	750 rides/hr
2000 Shoulder	464 rides/hr	3- 50 passenger bus	4 minutes	500 rides/hr
2000 Winter	187 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr
2010 Summer	830 rides/hr	4 - 50 passenger bus	3 minutes	875 rides/hr
2010 Shoulder	573 rides/hr	3 - 50 passenger bus	4 minutes	625 rides/hr
2010 Winter	240 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr

For the purposes of this analysis it was assumed that the existing bus fleet would be used to provide service on the West Rim and Yaki Point routes (routes common to all alternatives). The routes specific to this alternative would be served with new buses. Table 9 lists the total number of buses required for each season in the years 2000 and 2010. The fleet requirements shown in Table 9 do not include any of the existing NPS buses.

TABLE 9: Total Bus Fleet Requirements

Year/Season	50 Passenger LNG Buses (Active + Spares)	25 Passenger Battery Buses (Active +Spares)	Total Fleet (Active plus Spares)
2000 Summer	23 + 5 = 28	3 + 1 = 4	26 + 6 = 32
2000 Shoulder	16 + 3 = 19	2 + 1 = 3	18 + 4 = 22
2000 Winter	7 + 2 = 9	1 + 1 = 2	8 + 3 = 11
2010 Summer	28 + 6 = 34	4 + 1 = 5	32 + 7 = 39
2010 Shoulder	19 + 4 = 23	3 +1 = 4	22 + 5 = 27
2010 Winter	9 + 2 = 11	1 + 1 = 2	10 + 3 = 13

4.2 Bus System Personnel Requirements

The personnel requirements have been estimated at a rate of 3.5 employees per active bus in the fleet (not counting spare buses). This estimate covers drivers, mechanics, and administrative personnel. Table 10 shows the seasonal personnel requirements for the bus system for the years 2000 and 2010.

TABLE 10: Bus Personnel Requirements

Year/Season	Maximum Active Fleet	Personnel Required
2000 Summer	26	91
2000 Shoulder	18	63
2000 Winter	8	28
2010 Summer	32	112
2010 Shoulder	22	77
2010 Winter	10	35

4.3 Bus System Capital Cost
The capital costs for the bus service includes the rolling stock, a maintenance facility and a vehicle storage facility.

Bus - Rolling Stock
The cost of the rolling stock is based on 50 passenger, 40 foot-long, low-floor, LNG-powered buses and 25 passenger electric buses. The cost for the rolling stock is based on the fleet requirements for the peak summer ridership demand for the years 2000 and 2010. A unit price of $300,000 was estimated for each LNG bus and 275,000 for each battery powered bus that will be used on this system. The fleet requirements for the year 2000 are 28 LNG buses and 4 battery buses. The initial purchase cost for the fleet will be an estimated $9.5M. The ultimate fleet requirements for the 2010 demands will require a total fleet size of 34 LNG buses and 5 battery buses that will cost approximately $11.575M.

To properly assess the cost of using the fleet, it is necessary to calculate an annual depreciation value for the fleet. This was accomplished using an average service life of 15 years for the vehicles and an 8% rate of interest. This yields an annual use fee for the fleet of about $1.11M for the fleet needed in the year 2000 ($9,500,000 x 0.11683 = $1,109,885/year). In the year 2010 the full fleet requirements will increase the annual fee to about $1.35M per year ($11,575,000 x 0.11683 = $1,352,307/year).

Bus Maintenance Facility
The bus maintenance facility should be sized at the rate of one service bay per every 10 buses with a minimum of two bays. Each bay is estimated to be 2,000 sf. Additional space is required for tools, equipment, and parts. This space is estimated based on the number of service bays at the rate of 1,000 sf per bay. The administrative area for the transit operation will be included in the Maintenance facility. Maintenance facilities have been sized for the 2010 summer design values. An estimated unit price for the maintenance facility is $150 per square foot. (39 buses -- 4 bays x 3,000 sf = 12,000 sf building x $150/sf = $1,800,000)

In addition to the maintenance building, the bus fleet will also require a maintenance yard area for temporary vehicle storage and vehicle fueling. This area is anticipated to be paved and sized at the rate of 1,000 sf per bus. A cost of $200,000 per acre is estimated for the maintenance yard. (39 buses x 1,000 sf = 0.9 acres x $200,000/acre = $180,000)

The fleet will require a bus barn for night storage. The bus barn includes an unheated sheet metal building on a concrete slab floor with overhead lighting and electrical service only. The bus barn is sized based on 650 square feet per bus. A fleet of 39 buses will require a 25,350 square foot bus barn. Bus barns are estimated to cost approximately $20 per square foot. (39 buses x 650 sf = 25,350 sf x $20/sf = $507,000)

Bus System Capital Cost Summary
The following data summarizes the capital costs associated with the transit operation. The cost estimates shown in Table 11 are based on the 2010 design year needs and include all infrastructure costs except the cost of the rolling stock. The estimated $2.487M capital cost investment will be annualized using a 20 year pay back period and 8% interest. This yields an annualized cost of about $253,000 per year ($2,487,000 x 0.10185 = $253,300/year).

TABLE 11: Bus - Capital Cost Estimate*

Item	Units	Unit Price	Estimated Cost
Maintenance Building	12,000sf	$150/sf	$1,800,000
Maintenance Yard	0.9 acres	$200,000/acre	$ 180,000
Bus Barn	25,350sf	$20/sf	$ 507,000
TOTAL			**$2,487,000**

* Does not include rolling stock.

4.4 Bus System Operation and Maintenance Costs

The operation cost includes the labor, fuel, parts and maintenance. The transit operators contacted as part of the research indicated a range of operational costs. The lowest rate was $2.50 per mile and the highest rate was $4.50 per mile. For the purposes of this analysis an O&M cost of $3.50 per mile was considered appropriate for the year 2000 and a rate of $4.00 per mile for the year 2010. The increase in the O&M rate is to account for inflation. For the purposes of this calculation the daily miles driven was estimated using 90% of the full service hour miles driven.

The annual operating cost for the system in the year 2000 is estimated to be about $4.2M and in the year 2010 about $6M. A breakdown of the O&M costs is shown in Table 12.

TABLE 12: Bus - O&M Costs

Year and Season	Miles Driven Per Day	O&M Cost Per Day	O&M Cost Per Season
2000 Summer	5,456	$19,096	$1,737,736
2000 Shoulder	3,248	$11,368	$2,068,976
2000 Winter	1,339	$4,687	$426,472
2000 Total			**$4,233,184/Yr**
2010 Summer	6,704	$26,816	$2,440,256
2010 Shoulder	4,032	$16,128	$2,935,296
2010 Winter	1,703	$6,812	$619,892
2010 Total			**$5,995,444/Yr**

4.5 Bus System- Cost Per Visitor

A cost per visitor figure was developed using the 2010 data which includes the annual capital costs (20 year pay back with 8% interest) plus the O&M costs. This would be the fee that would have to be charged to each Park visitor to pay for the service. It is assumed that the cost of the transit system would by paid for by all visitors to the Park (North and South Rims, year-round) and not only the transit riders. The cost per visitor data is presented in Table 13.

TABLE 13: Bus System - Cost Per Visitor

	Year 2000	Year 2010
Annual O&M Cost	$4,233,184	$5,995,444
Annual Capital Cost*	$253,300	$253,300
Annual Fee for use of Rolling Stock	$1,109,885	$1,352,307
Total Annual Cost	**$5,596,369**	**$7,601,051**
Projected Annual Visitation	5,182,384	6,865,000
Cost Per Visitor	**$1.08**	**$1.11**

* Does not include cost for using rolling stock.

4.6 Bus Fleet Replacement Costs

The Park Service may desire to plan for the next generation of buses by assessing a fleet replacement fee. It is assumed that the next fleet will be needed in about 15 years and will cost considerably more than the present fleet due to inflation. Using a 3% annual inflation factor the next fleet is estimated to cost approximately $18M [($300,000 x 1.56 x 34 buses = $15,912,000) +($275,000 x 1.56 x 5 = $2,145,000)=$18,057,000]. Using an 8% interest factor the annual fleet replacement fee would be about $2.1M ($18,057,000 x 0.11683 = $2,109,599). If the annual fleet replacement fee were added to the per visitor cost it would yield a year 2000 cost of **$1.49** per visitor and a year 2010 cost of **$1.42** per visitor.

5. System Advantages and Disadvantages

Advantages

* Simple system to operate
* Simple grade separation at Center Road (no "Y" junction required)
*Both stations would be stub-end stations which eliminate the need for pedestrians to cross the light rail tracks
* This system can be constructed without interfering with the other transportation modes
* The double track nature of the design provides good failure management
*minimal road crossings
* All crossings of paved roads will be grade separated
* The light rail line is totally separate from the GCRR line thus eliminating any possible train to train conflicts.

Disadvantages

*The light rail system does not directly serve the Village
*This alternative requires the largest bus system
* The light rail vehicles will pass by the campground area when traveling both northbound and southbound
* The light rail system is isolated from the GCRR tracks and therefore the light rail vehicles and other rail equipment will have to be transported by truck to the site.

APPENDIX B
Design Parameters - Alternative 2
Visitor Transit System
Grand Canyon National Park, Arizona

This document is intended to provide the members of the Grand Canyon GMP Implementation Team with updated information about the design parameters related to the development of Alternative 2 for a visitor transit system within the Park. Alternative 2 includes a light rail passenger service operating between a parking area to be located outside of the Park near the north end of Tusayan, Mather Point and the Village. A fleet of buses operating on several fixed routes will be used to provide visitor circulation within the Village. Both the light rail and the bus service will operate year-round.

All visitors to the Village would be required to park at the lot in Tusayan and ride the light rail system to access Mather Point, and the Village. Overnight guest vehicles will be allowed on specific Park roads for the sole purpose of accessing their designated lodge parking area or campground. Tour buses will not be allowed access to Mather Point or the Village. Tour bus passengers will have use the light rail system and the bus system in order to visit Mather Point and all points to the west.

1. Visitor and Vehicle Projections

1.1 Design Day Calculations

<u>Assumptions used in Design Day calculations:</u>

1994 Total Visitation = 4,172,814	1994 South Rim Visitation = 3,751,014
2000 Total Visitation = 5,182,384	2000 South Rim Visitation = 4,722,259
2010 Total Visitation = 6,865,000	2010 South Rim Visitation = 6,341,000

<u>Modal Split</u>

For the purposes of this analysis the mode splits for the year 2000 are estimated to be 75% by car, 8.4% by shuttle bus, 13.6% by tour bus, and 3% by train. In the 2010 design year the modal splits are 72.7% by car, 9.3% by shuttle bus, 15% by tour bus and 3% by GCRR train.

<u>**YEAR 2000 - South Rim**</u>

<u>Summer Design Day 2000 = 37,554 visitors</u>
75% private veh. = 28,166 vis. by private veh./ 3.3 PPV = 8,535 veh. (8,180 cars & 355 RV's)
8.4% shuttle bus = 3,155 vis. by shuttle bus/ 31 PPV = 102 shuttle buses
13.6% tour bus = 5,107 vis. by tour bus/ 31 PPV = 165 tour buses
3% train = 1,127 vis. by train

<u>Winter Design Day 2000 = 12,855 visitors</u>
75% private veh. = 9,641 vis. by private veh./ 2.6 PPV = 3,708 veh. (3,542 cars & 166 RV's)
8.4% shuttle bus = 1,080 vis. by shuttle bus/ 31 PPV = 35 shuttle buses
13.6% tour bus = 1,748 vis. by tour bus/ 31 PPV = 56 tour buses
3% train = 386 vis. by train

YEAR 2010 - South Rim

Summer Design Day 2010 = 45,000 visitors
72.7% private veh. = 32,715 vis. by private veh./ 3.3 PPV = 9,914 veh. (9,502 cars & 412 RV's)
9.3% shuttle bus = 4,185 vis. by shuttle bus/ 31 PPV = 135 shuttle buses
15% tour bus = 6,750 vis. by tour bus/ 31 PPV = 218 tour buses
3% train = 1,350 vis. by train

Winter Design Day 2010 = 15,404 visitors
72.7% private veh. = 11,199 vis. by private veh./ 2.6 PPV = 4,307 veh. (4,130 cars & 177 RV's)
9.3% shuttle bus = 1,433 vis. by shuttle bus/ 31 PPV = 46 shuttle buses
15% tour bus = 2,311 vis. by tour bus/ 31 PPV = 75 tour buses
3% train = 462 vis. by train

2. Parking Requirements

Tusayan Parking Area
The parking area at Tusayan should be sized to accommodate the peak summer demand in 2010. The vehicle projections presented in the first section of this memo, an 80/20 split between the Village and the East Rim, and a 40% accumulation rate were used to estimate the parking requirements at the Tusayan site. It is estimated that the parking area should be sized to handle approximately 3,041 cars, 132 RV's, and 70 buses. Using 300 sf per car and 1,000 sf per bus and RV, the parking area would have a 25.6 acre paved surface.

3. Light Rail System Requirements

3.1 Light Rail Operation

The light rail portion of the transit system will operate between Tusayan, Mather Point, and the Village. The roadbed for the light rail system between Tusayan and Mather Point will be located in a dedicated right-of-way located to the west of and parallel to the South Entrance Road. The light rail system will be located in the roadway (South Entrance Road) for much of the route between Mather Point and the Village. A double track roadbed will be used for the entire system.

The tracks used for the light rail service will cross the Park road system at two locations between Tusayan and Mather Point. The main line will cross the access road to the existing "Dry Dump" maintenance area and Center Road. A concrete bridge structure will be used at both of these locations to enable road traffic to cross over the main line tracks of the light rail system. The light rail will operate in the road between Mather Point and the Village. The rail operation will be subject to the normal rules of the road through this section of the route. At-grade road crossings with the light rail system in this segment of the route will occur at two locations near the Business Center and at two locations on the Village Loop Road. Traffic at three of the four crossing locations will be limited to Park and concession personnel and Park buses. Overnight guests will be allowed to drive on the portion of Center Road that crosses the light rail line near the Maswik Transportation Center. Several high-use pedestrian paths will cross the light rail alignment in the vicinity of the Business Center and in the Village.

The light rail system will operate seven days a week year-round. During the summer season (June - August) light rail service with maximum vehicle headways of about six minutes will be available between the hours of 6 AM and 10 PM. Between the hours of 10 PM and 6 AM light rail service will be provided by a single vehicle operating on a one hour frequency. A separate on-demand dial-a-ride taxi service will also be available for a fee from the concessionaire between 10 PM and 6 AM.

During the shoulder seasons (September-November and March-May) the light rail service will operate between the hours of 7 AM and 9 PM. Maximum vehicle headways of about eight minutes will be maintained during the day the same as during the summer season. Evening light rail service between the hours of 9 PM and 7 AM will be similar to the summer night operation with hourly service.

During the winter season (December- February) the light rail service will be available between the hours of 7 AM and 8 PM. Maximum vehicle headways of about 10 minutes will be maintained during the day. Evening light rail service between the hours of 8 PM and 7 AM will be similar to the summer night operation with hourly service.

The round-trip route is approximately 17.7 miles in length. The average operating speed of the vehicles is 45 MPH for the section between Tusayan and Mather, and 20 MPH for the section between Mather and the Village. Stops for loading and unloading will occur at the four terminals (Tusayan, Mather, Business Center, and Maswik Transportation Center). A three minute station time is anticipated at the station in Tusayan and a four minute station time for the stations at Mather, the Business Center, and at Maswik. The three minute time at Tusayan was used assuming that there will not be any pedestrian crossing of the track in the vicinity of this station. The other three stations will have pedestrians crossing the tracks in or near the stations to access some of the loading platforms. As a result, a four minute station time was considered appropriate. The estimated round-trip travel time is 48 minutes including the stops. During peak periods during the summer and shoulder seasons light rail vehicles will be connected to form two-car trains. Each light rail vehicle will carry 175 passengers (seated plus standing) and provide a total of 219 rides per vehicle per hour (438 per 2-car train).

The transit system is sized to accommodate the peak hourly load. A peak hour factor of 13% of the daily demand was used. The 80% distribution factor was used the same as in the parking calculation. A total of 495 overnight guests (150 vehicles x 3.3 PPV) were subtracted from the peak hour summer transit demand. A total of 390 overnight guests (150 vehicles x 2.6 PPV) were subtracted from the peak hour transit demand during the shoulder and winter seasons.

Note that the shoulder season demand was estimated to be 70% of the summer demand value.

<u>2000 Summer Light Rail Demand</u>
Summer Design Day = 28,166 by car + 5,107 by tour bus = 33,273 visitors
Max. Transit demand = [(((33,273 x 80%) + 3,155 by shuttle bus) x 13%) - 495] = 3,376 rides/hr
Route Requirements = 3,376/219 = 16 light rail vehicles (8 two-car train units)
Vehicle Headway = 48/8 = 6 minutes
Fleet Requirements = 16 vehicles + 3 spares = **19 light rail vehicles**

<u>2000 Shoulder Light Rail Demand</u>
Shoulder Design Day = 19,716 by car + 3,575 by tour bus = 23,291 visitors
Max. Transit demand = [(((23,291 x 80%) + 2,209 by shuttle bus) x 13%) - 390] = 2,319 rides/hr
Route Requirements = 2,319/219 = 12 light rail vehicles (6 two-car trains)
Vehicle Headway = 48/6 = 8 minutes
Fleet Requirements = 12 vehicles + 3 spares = **15 light rail vehicles**

2000 Winter Light Rail Demand
Winter Design Day = 9,641 by car + 1,748 by tour bus = 11,389 visitors
Max. Transit demand = [(((11,389 x 80%) + 1,080 by shuttle) x 13%) -390] = 935 rides/hr
Route Requirements = 935/219 = 5 light rail vehicles
Vehicle Headway = 48/5 = 9.6 minutes
Fleet Requirements = 5 vehicles + 2 spares = **7 light rail vehicles**

2010 Summer Light Rail Demand
Summer Design Day = 32,715 by car + 6,750 by tour bus = 39,465 visitors
Max. Transit demand = [(((39,465 x 80%) + 4,185 by shuttle) x 13%) - 495] = 4,153 rides/hr
Route Requirements = 4,153/219 = 20 light rail vehicles (10 two-car train units)
Vehicle Headway = 48/10 = 4.8 minutes
Fleet Requirements = 20 vehicles + 4 spares = **24 light rail vehicles**

2010 Shoulder Light Rail Demand
Shoulder Design Day =22,901 by car + 4,725 by tour bus = 27,626 visitors
Max. Transit demand = [(((27,626 x 80%) + 2,930 by shuttle) x 13%) - 390] = 2,864 rides/hr
Route Requirements = 2,864/219 = 14 light rail vehicles (7 two-car trains)
Vehicle Headway = 48/7 = 6.9 minutes
Fleet Requirements = 14 vehicles + 3 spares = **17 light rail vehicles**

2010 Winter Light Rail Demand
Winter Design Day = 11,199 by car + 2,311 by tour bus = 13,510 visitors
Max. Transit demand = [(((13,510 x 80%) + 1,433 by shuttle) x 13%) -390] = 1,201 rides/hr
Route Requirements = 1,201/219 = 6 light rail vehicles
Vehicle Headway = 48/6 = 8 minutes
Fleet Requirements = 6 vehicles + 2 spares = **8 light rail vehicles**

Table 1 summarizes the light rail requirements for each season for the years 2000 and 2010.

TABLE 1: Light Rail System Requirements

Year/Season	Demand	Light Rail Vehicles Required (Route requirements plus spares)	Headway
2000 Summer	3,376 Rides/hr.	16 + 3 = 19	6 minutes
2000 Shoulder	2,319 Rides/hr.	12 + 3 = 15	8 minutes
2000 Winter	935 Rides/hr.	5 + 2 = 7	9.6 minutes
2010 Summer	4,153 Rides/hr.	20 + 4 = 24	4.8 minutes
2010 Shoulder	2,864 Rides/hr.	14 + 3 = 17	6.9 minutes
2010 Winter	1,201 Rides/hr.	6 + 2 = 8	8 minutes

3.2 Light Rail System Personnel Requirements

The personnel requirements have been estimated based on a rate of 3 employees per active light rail vehicle in operation during peak periods (with a minimum of 12 employees). This estimate covers drivers, mechanics, and administrative personnel. The personnel estimates presented in Table 2 are based on the seasonal requirements in the years 2000 and 2010.

TABLE 2: Light Rail Personnel Requirements

Year/Season	Maximum Active Trains	Personnel Required
2000 Summer	16	48
2000 Shoulder	12	36
2000 Winter	5	15
2010 Summer	20	60
2010 Shoulder	14	42
2010 Winter	6	18

3.3 Light Rail System Capital Cost

The full-build (year 2010) light rail system capital cost was estimated to be $81.78M in 1997 dollars. A subsystem breakdown of this cost is provided in Table 3.

Recent light rail system costs were reviewed from FTA aggregate data as well as specific detailed cost data from L.A. LRT Blue Line, St. Louis LRT and San Francisco BART (RRT) projects. The high level of detail in this cost data allowed both bottom-up and top-down cost estimating approaches to be used. Data was adjusted for grade (at-grade), time (1997) and location. Costs were adjusted for location using the Engineering News Record's cost index for 22 U.S. cities, including Los Angeles, St. Louis and San Francisco. For some items an additional bottom-up approach using the 1997 RS Means Heavy Construction Cost Data was employed.

TABLE 3: Light Rail System - Capital Cost Summary

Subsystem	Unit	Quantity	Unit Cost	Total Cost
DMU Vehicles	vehicles	24	$1,350,000	$32,400,000
Sub Grade & Track	dual-lane miles	8.85	$1,860,000	$16,461,000
Excavation	cubic yards	199,574	$8.32	$1,660,456
Embankment	cubic yards	211,000	$7.48	$1,578,280
Train Control	dual-lane miles	2.2	$1,960,000	$4,312,000
Stations	stations	4	$815,000	$3,260,000
Maintenance Facility	vehicles	24	$220,000	$5,280,000
Grade Separation at Center Road	---	---	---	$776,390
Grade Separation at Maintenance Road	---	---	---	$990,134
Pavement Removal and Replacement	square feet	216,540	$6.60	$1,429,164
Engineering / Proj. Mgmt.	percent	20%	---	$13,629,485
Total Costs				**$81,776,909**

It is unclear whose jurisdiction this project would fall under: the Federal Transit Administration (FTA), the Federal Railroad Administration (FRA), or possibly a State of Arizona body. Hazards analysis, quality control, quality assurance, schedule adherence, interface coordination and third-party oversight are all mechanisms which can provide the Park Service the proper level of comfort required to undertake this project. The level of detail to which these items can be taken can vary widely. These items are accounted for in the engineering and project management component of the cost estimate.

Light Rail - Rolling Stock

A total of 24 vehicles is specified for the year 2010 with 20 operating in the peak period and four spares. This spare ratio is considered adequate. Recent light rail vehicle costs were reviewed and adjusted for time, location and power source. The ABB/ADtranz RegioShuttle and the Bombardier Target add the potential for direct vehicle supplier competition which will keep the vehicle cost down. Assuming supplier competition, a recommended budgetary cost for DMU rail vehicles is $1.35 million per vehicle or $32.4M for the entire fleet.

Light Rail Track, Switches and Train Control

The light rail system in this alternative consists of approximately 8.85 miles of dual lane track. Ballast and sub ballast quantities were estimated for a fully loaded RegioSprinter. Other components included clear&grub, grading, embankment, underdrain, service road aisle and ballasted track procurement and installation. Given the quantities determined above, sub-grade and track has a unit cost of $1,860,000 per dual-lane mile for a total cost of $16.5M. The unit cost was estimated from both a top-down method and a bottom-up method. The top-down method incorporated total trackwork costs from FTA data (average and low), L.A. Blue Line and St. Louis LRT projects. The bottom-up method used 1997 Means Construction costs for 90 and 115 pound Relay Rail, ties, ballast, sub ballast, installation (crew) and alignment.

Components within excavation include hauling of materials, drilling and blasting, backfill and grading. Components within embankment include hauling of materials, backfill and grading. From the quantities provided, it was estimated the alignment would have approximately 200,000 cubic yards of excavation and 211,000 cubic yards of embankment. Excavation and embankment had unit costs of $8.32 and $7.48 per cubic yard respectively. Total excavation costs were $1.66M and total embankment costs were $1.58M. Unit costs were estimated from both a top-down method and a bottom-up method. The top-down method incorporated total trackwork costs from FTA data (average and low), L.A. Blue Line and St. Louis LRT projects. The bottom-up method used 1997 Means cost data.

It was assumed that train control or signalization would be implemented at the stations, along the steepest grade (3.5 and 4.0 percent) trackwork, crossovers, turnouts and road crossings. This resulted in approximately 25 percent or 2.2 dual-lane miles of the alignment having signalization. The alignment has four stations which require signalization. The signal system and its associated cost can range from simple vehicle detection systems for grade crossing protection to fully automated systems that require little or no train operator actions. For this alignment it is assumed that a fixed block-type train control system using wayside signal lights would be used with provisions for interlocking. Train control had a unit cost of $1.96 million per dual-lane mile which was estimated from both a top-down method and a bottom-up method. The total train control cost was $4.3M.

Roadway/Light Rail Grade-Separated Crossings

Two grade-separated crossings will be required. One crossing will be with Center Road, where the light rail will pass under the road in the existing drainage channel. The other crossing will be where the light rail will pass under the maintenance road that leads to the maintenance area. In both cases the roadway will need to be elevated and new concrete bridge spans installed. The cost estimates are shown below:

Crossing #1: Center Road & Light Rail

Approach Fill Req'd: 9,500 cubic meters (@ $9.00 per c.m.)= $85,000
Roadway Removal Req'd: 2,160 square meters (@ $6.00 per sq. m.)= $12,960
New Roadway Req'd: 29,527 square feet (@ $6.00 per sq. ft.)= $177,162
Total Bridge Cost: $400,000 (@ $80 per sq. ft.)

Subtotal Const.	= $675,122
15% Contingency	= $101,268
TOTAL COST	**= $776,390**

Crossing #2: Maintenance Access Road & Light Rail

Approach Fill Req'd: 22,350 cubic meters (@ $9.00 per c.m.)= $201,150
Roadway Removal Req'd: 2,952 square meters (@ $6.00 per sq. m.)= $17,712
New Roadway Req'd: 40,354 square feet (@ $6.00 per sq. ft.)= $242,124
Total Bridge Cost: $400,000 (@ $80 per sq. ft.)

Subtotal Const.	= $860,986
15% Contingency	= $129,148
TOTAL COST	**= $990,134**

Pavement Removal and Replacement

The light rail alignment in this alternative is concurrent with the Park road system for a portion of the route between Mather Point and the Village. A cost estimate is provided for the road work required to install the light rail tracks in the roadway. The cost estimate is based on the number of square feet of pavement removal and replacement. It was estimated that both lanes of the existing roadway would have to be removed and replaced in order to incorporate the tracks into the road. A total of 216,540 square feet of pavement will have to be removed and replaced. A unit cost of $6.60 per square foot was considered appropriate for this work. The total cost of this work element is estimated to be approximately $1.43M.

Light Rail Stations

The alignment has four stations (Tusayan, Mather Point, Business Center, and Maswik), all of which would be at-grade stations. The Tusayan and the Maswik stations would be terminating (end-of-line) stations and could be designed with loading platforms on both sides of each track without the need to have any pedestrians cross the tracks. The Mather Point and Business Center Stations will be in-line stations. These stations should be designed with loading platforms on both sides of each track. Because these are in-line stations, with through train traffic, the visitors will be required to cross the tracks to access some of the loading platforms. An at-grade pedestrian crossing of the tracks will be required in the design of these stations. Recent light rail at-grade station costs were reviewed and adjusted for time, location and assumed number of platforms per station. The resulting cost of a typical side-center-side platform at-grade light rail station is $815,000 for a total station cost of $3.26M. It is assumed the Park Service would pay for all station costs.

Light Rail Maintenance Facility
The maintenance facility cost was estimated using unit costs from recently constructed light rail system maintenance facilities, adjusted for time and location. Adjusted light rail maintenance facility costs were found to be approximately $220,000 per vehicle. The total cost of the facility was estimated to be $4.18M.

Light Rail Engineering/Project Management
Typically on FTA funded light rail transit projects, these are 25 to 30 percent of the total construction costs. These projects fall under the jurisdiction of the FTA, whose regulations are relatively extensive. With it unclear whose jurisdiction this project would fall under, it is recommended that an engineering and project management estimate of 20 percent of the total construction costs be used for a total cost of $13.4M. This reduced percentage assumes less onerous regulations and compliance than on FTA work.

3.4 Light Rail Operation and Maintenance Costs
For the year 2000, total annual operation and maintenance costs were estimated to be approximately $5.2M. From an operations analysis, an annual total of 53,808 vehicle hours were calculated. A cost of $96.90 per vehicle revenue hour was used. FTA data for light rail operating costs per vehicle revenue hour has a low of $36.90 and an average of $153.73.

For the year 2010, total operations and maintenance costs were estimated to be $7.12M. From the operations analysis, an annual total of 64,701 vehicle hours were determined. A cost of $110.00 per vehicle revenue hour was used for the 2010 O&M estimate.

3.5 Light Rail - Cost per Visitor
The cost per visitor for the light rail system is identified in Table 4 below:

TABLE 4: Light Rail Cost Per Visitor

	Year 2000	Year 2010
Annual Capital Cost*	$9,399,781	$9,399,781
Annual O & M Cost	$5,213,995	$7,117,110
Total Annual Cost	$14,613,776	$16,516,891
Visitation	5,182,384	6,865,000
Cost per Visitor	**$2.82**	**$2.41**

*$80,456,909 x .11683 =$9,399,781/yr based on 8% for 15 yrs

4. Bus System Requirements

4.1 Bus System Operation
A fleet of buses will provide for the visitor transportation needs in those areas of the village that are not served directly by the light rail system. The bus fleet will likely consist of 50 passenger LNG buses and 25 passenger battery powered buses. The battery buses are planned for use on the route serving Yavapai Observation Point, while the LNG buses are planned for all of the other routes included in this alternative. All of the buses in the fleet will be designed to have a low floor (14 inches or less) with wide doors opening on the right side of the vehicle.

The bus system will operate seven days a week year-round. bus service will be available between the hours of 6 AM and 10 PM during the summer, 7 AM and 9 PM during the shoulder season, and 7 AM and 8 PM during the winter. Vehicle headways will vary depending on the route and season. In most cases the headways will always be 20 minutes or less. A separate on-demand dial-a-ride taxi service will be available for a fee from the concessionaire during the night after the bus service has ended.

In addition to the bus service that is common to all alternatives (West Rim, Yaki Point) this alternative includes additional buses operating on three other fixed routes. These routes include Mather - Yavapai Museum, Business Center Loop, and Village Loop. These routes are described below:

Mather-Yavapai Museum Route - 3.0 mile round trip route (25 MPH avg. speed)
2 stops (2 min/stop) - Mather Point and Yavapai Museum
12 minute round trip travel time.

Demand Assumption:

The bus service will be used to regulate the visitor flow to the museum. Anticipated demand will be greatly influenced by the specific loading location at Mather, the frequency of the buses and the amount of marketing performed. It is likely that this demand could increase significantly if the route were highly advertised. Actual demand is unknown. For the purposes of this analysis it is assumed that demand for this bus service will be 10% of the light rail demand. It is assumed that 25 passenger, battery powered buses will be used on this route. The service requirements of this route are shown in Table 5.

TABLE 5: Mather - Yavapai Museum Bus Route

Year/Season	Estimated Demand	Buses Required	Headway	Transit Supply
2000 Summer	338 rides/hr	3 - 25 passenger buses	4 minutes	375 rides/hr
2000 Shoulder	232 rides/hr	2 - 25 passenger buses	6 minutes	250 rides/hr
2000 Winter	94 rides/hr	1 - 25 passenger bus	12 minutes	125 rides/hr
2010 Summer	415 rides/hr	4 - 25 passenger buses	3 minutes	500 rides/hr
2010 Shoulder	286 rides/hr	3 - 25 passenger buses	4 minutes	375 rides/hr
2010 Winter	120 rides/hr	1 - 25 passenger bus	12 minutes	125 rides/hr

Business Center Loop Bus Route - 2.2 mile round trip route (20 MPH avg. speed)
5 stops (1 min/stop)- Business Center, Yavapai Lodge, Yavapai East, Campground, and RV Park
12 minute round trip travel time

Demand Assumption:

This route will primarily serve overnight guests wishing to circulate between the developments in the vicinity of the Business Center. The number of day visitors that will use this bus route is believed to be relatively small. This route also serves as the only bus access to the Yavapai Lodge, the campground, and RV park. These overnight accommodations represent about 800 guest units serving approximately 2,640 overnight guests during the summer months. Many of these overnight guests will ride this bus to access their lodge or camping area. The overnight guests will likely use this bus to circulate throughout the business area and will transfer to the Mather -Village Bus Route to access the other areas of the Village.

The number of guests staying in the campground, RV park, and the Yavapai Lodge will remain constant over time**.** It is estimated that during the peak hour of the day during the summer the overnight guests staying at the facilities in the vicinity of the Business Center will generate a ridership demand of 343 rides/hr (based on a 13% peak hour factor). It was estimated that the overnight guests would generate 240 rides/hr (70% of summer) for the shoulder season and 86 rides/hr (25% of summer) for the winter season. Table 7 shows the service requirements of this route.

TABLE 7: Business Center Loop Bus Route

Year/Season	Estimated Demand	Buses Required	Headway	Transit Supply
2000 Summer	343 rides/hr	2 - 50 passenger buses	6 minutes	500 rides/hr
2000 Shoulder	240 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr
2000 Winter	86 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr
2010 Summer	343 rides/hr	2 - 50 passenger buses	6 minutes	500 rides/hr
2010 Shoulder	240 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr
2010 Winter	86 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr

Village Loop Bus Route - 1.75 mile route (20 MPH avg. speed)
6 stops - (1 min/stop) El Tovar, Bright Angle, West Rim Interchange, Maswik Lodge, Maswik T.C., and Heritage Campus
12 minute round trip travel time
Summer 2010 demand = 25% of rail demand = 1,038 rides/hr

Demand Assumptions:

This bus route will circulate throughout the Village with a stop at the Light Rail station. The current bus service on the Village Loop provides the equivalent of about 500 rides per hour (over the length of the entire route). Without their vehicles the visitor is expected to rely more on this route for moving about the Village. It is estimated that the demand for this bus service will be 20% of the light rail demand. For the purposes of this analysis it is assumed that 25 passenger battery powered buses would be used on the Village Loop Bus Route. The service requirements of the Village Loop Bus Route are shown in Table 8.

Note that during the winter season it may be desirable to use two 25 passenger battery powered buses for the Village Loop instead of the single 50 passenger vehicle that is used on this route during the rest of the year. The use of two of the smaller buses on this route during the winter months would produce a more desirable headway of 6 minutes versus the 12 minute headway shown in Table 8.

TABLE 8: Village Loop Bus Route

Year/Season	Estimated Demand	Buses Required	Headway	Transit Supply
2000 Summer	675 rides/hr	3 - 50 passenger bus	4 minutes	750 rides/hr
2000 Shoulder	464 rides/hr	3- 50 passenger bus	4 minutes	500 rides/hr
2000 Winter	187 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr
2010 Summer	830 rides/hr	4 - 50 passenger bus	3 minutes	875 rides/hr
2010 Shoulder	573 rides/hr	3 - 50 passenger bus	4 minutes	625 rides/hr
2010 Winter	240 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr

For the purposes of this analysis it was assumed that the existing bus fleet would be used to provide service on the West Rim and Yaki Point routes (routes common to all alternatives). The routes specific to this alternative would be served with new buses. Table 9 lists the total number of buses required for each season in the years 2000 and 2010. The fleet requirements shown in Table 9 do not include any of the existing NPS buses.

TABLE 9: Total Bus Fleet Requirements

Year/Season	50 Passenger LNG Buses (Active + Spares)	25 Passenger Battery Buses (Active +Spares)	Total Fleet (Active plus Spares)
2000 Summer	5 + 2 = 7	3 + 1 = 4	8 + 3 = 11
2000 Shoulder	4 + 1 = 5	2 + 1 = 3	6 + 2 = 8
2000 Winter	2 + 1 = 3	1 + 1 = 2	3 + 2 = 5
2010 Summer	6 + 2 = 8	4 + 1 = 5	10 + 3 = 13
2010 Shoulder	4 + 1 = 5	3 +1 = 4	7 + 2 = 9
2010 Winter	2 + 1 = 3	1 + 1 = 2	3 + 2 = 5

4.2 Bus System Personnel Requirements

The personnel requirements have been estimated at a rate of 3.5 employees per active bus in the fleet (not counting spare buses). This estimate covers drivers, mechanics, and administrative personnel. Table 10 shows the seasonal personnel requirements for the bus system for the years 2000 and 2010.

TABLE 10: Bus Personnel Requirements

Year/Season	Maximum Active Fleet	Personnel Required
2000 Summer	8	28
2000 Shoulder	6	21
2000 Winter	3	11
2010 Summer	10	35
2010 Shoulder	7	25
2010 Winter	3	11

4.3 Bus System Capital Cost

The capital costs for the bus service includes the rolling stock, a maintenance facility and a vehicle storage facility.

Bus - Rolling Stock
The cost of the rolling stock is based on 50 passenger, 40 foot-long, low-floor, LNG-powered buses and 25 passenger battery-powered buses. The cost for the rolling stock is based on the fleet requirements for the peak summer ridership demand for the years 2000 and 2010. A unit price of $300,000 was estimated for each LNG bus and $275,000 for each battery powered bus that will be used on this system. The fleet requirements for the year 2000 are 7 LNG buses and 4 battery buses. The initial purchase cost for the fleet will be an estimated $3.2M. The ultimate fleet requirements for the 2010 demands are a total fleet size of 8 LNG buses and 5 battery buses that will cost approximately $3.775M.

To properly assess the cost of using the fleet, it is necessary to calculate an annual depreciation value for the fleet. This was accomplished using an average service life of 15 years for the vehicles and an 8% rate of interest. This yields an annual use fee for the year 2000 fleet of about $374,000 ($3,200,000 x 0.11683 = $373,856/year). In the year 2010 the full fleet requirements will increase the annual fee to about $441,000 per year ($3,775,000 x 0.11683 = $441,033/year).

Bus Maintenance Facility
The bus maintenance facility should be sized at the rate of one service bay per every 10 buses with a minimum of two bays. Each bay is estimated to be 2,000 sf. Additional space is required for tools, equipment, and parts. This space is estimated based on the number of service bays at the rate of 1,000 sf per bay. The administrative area for the transit operation will be included in the maintenance facility. Maintenance facilities have been sized for the 2010 summer design values. An estimated unit price for the maintenance facility is $150 per square foot. (13 buses -- 2 bays x 3,000 sf = 6,000 sf building x $150/sf = $900,000)

In addition to the maintenance building, the bus fleet will also require a maintenance yard area for temporary vehicle storage and vehicle fueling. This area is anticipated to be paved and sized at the rate of 1,000 sf per bus. A cost of $200,000 per acre is estimated for the maintenance yard. (13 buses x 1,000 sf = 0.3 acres x $200,000/acre = $60,000)

The fleet will require a bus barn for night storage. The bus barn includes an unheated sheet metal building on a concrete slab floor with overhead lighting and electrical service only. The bus barn is sized based on 650 square feet per bus. A fleet of 13 buses will require a 8,450 square foot bus barn. Bus barns are estimated to cost approximately $20 per square foot. (13 buses x 650 sf = 8,450 sf x $20/sf = $169,000)

Bus System Capital Cost Summary
The following data summarizes the capital costs associated with the transit operation. The cost estimates shown in Table 11 are based on the 2010 design year needs and include all infrastructure costs except the cost of the rolling stock. The estimated $1.129M capital cost investment will be annualized using a 20 year pay back period and 8% interest. This yields an annualized cost of about $115,000 per year ($1,129,000 x 0.10185 = $114,989/year).

TABLE 11: Bus - Capital Cost Estimate*

Item	Units	Unit Price	Estimated Cost
Maintenance Building	6,000sf	$150/sf	$900,000
Maintenance Yard	0.3 acres	$200,000/acre	$ 60,000
Bus Barn	8,450sf	$20/sf	$169,000
TOTAL			**$1,129,000**

* Does not include rolling stock.

4.4 Bus System Operation and Maintenance Costs
The operation cost includes the labor, fuel, parts and maintenance. The transit operators contacted as part of the research indicated a range of operational costs. The lowest rate was $2.50 per mile and the highest rate was $4.50 per mile. For the purposes of this analysis an O&M cost of $3.50 per mile was considered appropriate for the year 2000 and a rate of $4.00 per mile for the year 2010. The increase in the O&M rate is to account for inflation. For the purposes of this calculation the daily miles driven was estimated using 90% of the full service hour miles driven.

The annual operating cost for the system in the year 2000 is estimated to be about $1.1M and in the year 2010 about $1.5M. A breakdown of the O&M costs is shown in Table 12.

TABLE 12: Bus - O&M Costs

Year and Season	Miles Driven Per Day	O&M Cost Per Day	O&M Cost Per Season
2000 Summer	1,343	$4,701	$427,791
2000 Shoulder	847	$2,965	$539,630
2000 Winter	407	$1,425	$129,675
2000 Total			**$1,097,096/Yr**
2010 Summer	1,685	$6,740	$613,340
2010 Shoulder	1,036	$4,144	$754,208
2010 Winter	407	$1,628	$148,148
2010 Total			**$1,515,696/Yr**

4.5 Bus System- Cost Per Visitor
A cost per visitor figure was developed using the 2010 data which includes the annual capital costs (20 year pay back with 8% interest) plus the O&M costs. This would be the fee that would have to be charged to each Park visitor to pay for the service. It is assumed that the cost of the transit system would by paid for by all visitors to the Park (North and South Rims, year-round) and not only the transit riders. The cost per visitor data is presented in Table 13.

TABLE 13: Bus System - Cost Per Visitor

	Year 2000	Year 2010
Annual O&M Cost	$1,097,096	$1,515,696
Annual Capital Cost*	$114,989	$114,989
Annual Fee for use of Rolling Stock	$373,856	$441,033
Total Annual Cost	**$1,585,941**	**$2,071,718**
Projected Annual Visitation	5,182,384	6,865,000
Cost Per Visitor	**$0.31**	**$0.30**

* Does not include cost for using rolling stock.

4.6 Bus Fleet Replacement Costs

The Park Service may desire to plan for the next generation of buses by assessing a fleet replacement fee. It is assumed that the next fleet will be needed in about 15 years and will cost considerably more than the present fleet due to inflation. Using a 3% annual inflation factor the next fleet is estimated to cost approximately $5.89M [($300,000 x 1.56 x 8 buses = $3,744,000) +($275,000 x 1.56 x 5 = $2,145,000)=$5,889,000]. Using an 8% interest factor the annual fleet replacement fee would be about $688,000 ($5,889,000 x 0.11683 = $688,012). If the annual fleet replacement fee were added to the per visitor cost it would yield a year 2000 cost of **$0.44** per visitor and a year 2010 cost of **$0.43** per visitor.

5. System Advantages and Disadvantages

Advantages

* System provides rail access to several areas within the Park
* Simple system to operate
* Simple grade separation at Center Road (no “Y” junction required)
* The double track nature of the design provides good failure management
* System provides village access with a minimal amount of vegetated area disturbed between Mather Point and the Village
* Requires a small bus fleet to complement the rail service
* The light rail system can be easily access from the GCRR tracks and therefore the light rail vehicles and other rail equipment can be delivered by rail and transported from the site for heavy maintenance

Disadvantages

*The light rail alignment passes through the Historic Village
* Noise, air quality and visual impacts from the rail vehicles will occur in the vicinity of the Business Center and in the Village
* The route includes a long uphill grade when exiting the Village resulting in greater noise and air quality impacts in the Village area as the vehicles pull the grade
*The stations at Mather Point and the Business Center will be in-line stations with trains traveling in both directions combined with pedestrian traffic crossing the tracks in these stations to get to the loading platforms
*The right rail vehicles will pass through areas of the Village that will have large numbers of pedestrian traffic
*Light rail vehicles will pass through the Village, Business Center, and Mather Point when exiting the Village on the route back to Tusayan

*The light rail vehicles will pass by the campground area when traveling both northbound and southbound
* The cost to the visitor for the transportation service is relatively high

APPENDIX C
Design Parameters - Alternative 3
Visitor Transit System
Grand Canyon National Park, Arizona

This document is intended to provide the members of the Grand Canyon GMP Implementation Team with updated information about the design parameters related to the development of Alternative 3 for a visitor transit system within the Park. Alternative 3 includes a light rail passenger service operating between a parking area to be located outside of the Park near the north end of Tusayan, Mather Point and the Village. A fleet of buses operating on several fixed routes will be used to provide visitor circulation within the Village. Both the light rail and the bus service will operate year-round.

All visitors to the Village would be required to park at the lot in Tusayan and ride the light rail system to access Mather Point, and the Village. Overnight guest vehicles will be allowed on specific Park roads for the sole purpose of accessing their designated lodge parking area or campground. Tour buses will not be allowed access to Mather Point or the Village. Tour bus passengers will have use the light rail system and the bus system in order to visit Mather Point and all points to the west.

1. Visitor and Vehicle Projections

1.1 Design Day Calculations

<u>Assumptions used in Design Day calculations:</u>

1994 Total Visitation = 4,172,814	1994 South Rim Visitation = 3,751,014
2000 Total Visitation = 5,182,384	2000 South Rim Visitation = 4,722,259
2010 Total Visitation = 6,865,000	2010 South Rim Visitation = 6,341,000

<u>Modal Split</u>

For the purposes of this analysis the mode splits for the year 2000 are estimated to be 75% by car, 8.4% by shuttle bus, 13.6% by tour bus, and 3% by train. In the 2010 design year the modal splits are 72.7% by car, 9.3% by shuttle bus, 15% by tour bus and 3% by GCRR train.

<u>YEAR 2000 - South Rim</u>

<u>Summer Design Day 2000 = 37,554 visitors</u>

75% private veh. = 28,166 vis. by private veh./ 3.3 PPV = 8,535 veh. (8,180 cars & 355 RV's)
8.4% shuttle bus = 3,155 vis. by shuttle bus/ 31 PPV = 102 shuttle buses
13.6% tour bus = 5,107 vis. by tour bus/ 31 PPV = 165 tour buses
3% train = 1,127 vis. by train

<u>Winter Design Day 2000 = 12,855 visitors</u>

75% private veh. = 9,641 vis. by private veh./ 2.6 PPV = 3,708 veh. (3,542 cars & 166 RV's)
8.4% shuttle bus = 1,080 vis. by shuttle bus/ 31 PPV = 35 shuttle buses
13.6% tour bus = 1,748 vis. by tour bus/ 31 PPV = 56 tour buses
3% train = 386 vis. by train

YEAR 2010 - South Rim
Summer Design Day 2010 = 45,000 visitors
72.7% private veh. = 32,715 vis. by private veh./ 3.3 PPV = 9,914 veh. (9,502 cars & 412 RV's)
9.3% shuttle bus = 4,185 vis. by shuttle bus/ 31 PPV = 135 shuttle buses
15% tour bus = 6,750 vis. by tour bus/ 31 PPV = 218 tour buses
3% train = 1,350 vis. by train

Winter Design Day 2010 = 15,404 visitors
72.7% private veh. = 11,199 vis. by private veh./ 2.6 PPV = 4,307 veh. (4,130 cars & 177 RV's)
9.3% shuttle bus = 1,433 vis. by shuttle bus/ 31 PPV = 46 shuttle buses
15% tour bus = 2,311 vis. by tour bus/ 31 PPV = 75 tour buses
3% train = 462 vis. by train

2. Parking Requirements

Tusayan Parking Area
The parking area at Tusayan should be sized to accommodate the peak summer demand in 2010. The vehicle projections presented in the first section of this memo, an 80/20 split between the Village and the East Rim, and a 40% accumulation rate were used to estimate the parking requirements at the Tusayan site. It is estimated that the parking area should be sized to handle approximately 3,041 cars, 132 RV's, and 70 buses. Using 300 sf per car and 1,000 sf per bus and RV, the parking area would have a 25.6 acre paved surface.

3. Light Rail System Requirements

3.1 Light Rail Operation
The light rail portion of the transit system will operate between Tusayan, Mather Point, and the Village. The route will include a double track line between Tusayan and Center Road where the tracks split to create a counter-clockwise single-track loop with stations at Mather Point, the Business Center and the Maswik Transportation Center. The roadbed for the light rail system between Tusayan and Mather Point will be located in a dedicated right-of-way located to the west of and parallel to the South Entrance Road. The light rail system will be located in the roadway (South Entrance Road) for much of the route between Mather Point and the Village. From Maswik back to the junction near the South Entrance Road/Center Road intersection the rail alignment will be a dedicated right-of-way on the south side and generally parallel to Center Road. Rail sidings will be provided at each of the stations in the Park for failure management. These sidings will enable a stalled rail vehicle to be pushed out of the way in the event of a breakdown.

The tracks used for the light rail service will cross the Park road system at two locations between Tusayan and Mather Point. The main line will cross the access road to the existing “Dry Dump” maintenance area and Center Road. A concrete bridge structure will be used at both of these locations to enable road traffic to cross over the main line tracks of the light rail system. The light rail will operate in one lane of the road between Mather Point and the Village. The rail operation will be subject to the normal rules of the road through this section of the route. At-grade road crossings with the light rail system in this segment of the route will occur at two locations near the Business Center and at two locations on the Village Loop Road. Traffic at three of the four crossing locations will be limited to Park and concession personnel and Park buses. Overnight guests will be allowed to drive on the portion of Center Road that crosses the light rail line near the Maswik Transportation Center. Several high-use pedestrian paths will cross the light rail alignment in the vicinity of the Business Center and in the

Village.

The light rail service in this alternative includes the main-line operation on the full loop from Tusayan to the Park and back, as well as a local service that travels only on the smaller loop that circulates around the Village. The local service will travel in the same counter-clockwise direction and on the same single track loop as the main-line service.

The light rail system will operate seven days a week year-round. During the summer season (June - August) light rail service with maximum vehicle headways of about six minutes will be available between the hours of 6 AM and 10 PM. Between the hours of 10 PM and 6 AM light rail service will be provided by a single vehicle operating on a one hour frequency. A separate on-demand dial-a-ride taxi service will also be available for a fee from the concessionaire between 10 PM and 6 AM.

During the shoulder seasons (September-November and March-May) the light rail service will operate between the hours of 7 AM and 9 PM. Maximum vehicle headways of about eight minutes will be maintained during the day the same as during the summer season. Evening light rail service between the hours of 9 PM and 7 AM will be similar to the summer night operation with hourly service.

During the winter season (December- February) the light rail service will be available between the hours of 7 AM and 8 PM. Maximum vehicle headways of about 10 minutes will be maintained during the day. Evening light rail service between the hours of 8 PM and 7 AM will be similar to the summer night operation with hourly service.

<u>Main-Line Light Rail Service</u>
The main-line round-trip route is approximately 15.1 miles in length. The average operating speed of the vehicles is 45 mph for the section between Tusayan and Mather, 20 mph for the section between Mather and Maswik, and 30 mph for the section from Maswik back to the main line near the Center Road junction. Stops for loading and unloading will occur at the four terminals (Tusayan, Mather, Business Center, and Maswik Transportation Center). A three minute station time is anticipated at the station in Tusayan and a four minute station time for the stations at Mather, the Business Center, and at Maswik. The three minute time at Tusayan was used assuming that there will not be any pedestrian crossing of the track in the vicinity of this station. The other three stations will have pedestrians crossing the tracks in or near the stations to access some of the loading platforms. As a result, a four minute station time was considered appropriate. The estimated main-line round-trip travel time is 40 minutes including the stops. During peak periods during the summer and shoulder seasons the light rail vehicles will be connected together to form two-car trains. Each light rail vehicle operating on the main-line will carry 175 passengers (seated plus standing) and provide a total of 263 rides per vehicle per hour (525 per two-car train).

The transit system is sized to accommodate the peak hourly load. A peak hour factor of 13% of the daily demand was used. The 80% distribution factor was used the same as in the parking calculation. A total of 495 overnight guests (150 vehicles x 3.3 PPV) were subtracted from the peak hour summer transit demand. A total of 390 overnight guests (150 vehicles x 2.6 PPV) were subtracted from the peak hour transit demand during the shoulder and winter seasons.

Note that the shoulder season demand was estimated to be 70% of the summer demand value. The following demand calculations apply only to the demand for the main-line operation.

<u>2000 Summer Light Rail Demand</u>

Summer Design Day = 28,166 by car + 5,107 by tour bus = 33,273 visitors
Max. Transit demand = [(((33,273 x 80%) + 3,155 by shuttle bus) x 13%) - 495] = 3,376 rides/hr
Route Requirements = 3,376/263 = 14 light rail vehicles (7 two-car train units)
Vehicle Headway = 40/7 = 5.7 minutes
Fleet Requirements = 14 vehicles + 3 spares = **17 light rail vehicles**

<u>2000 Shoulder Light Rail Demand</u>
Shoulder Design Day = 19,716 by car + 3,575 by tour bus = 23,291 visitors
Max. Transit demand = [(((23,291 x 80%) + 2,209 by shuttle bus) x 13%) - 390] = 2,319 rides/hr
Route Requirements = 2,319/263 = 10 light rail vehicles (5 two-car trains)
Vehicle Headway = 40/5 = 8 minutes
Fleet Requirements = 10 vehicles + 2 spares = **12 light rail vehicles**

<u>2000 Winter Light Rail Demand</u>
Winter Design Day = 9,641 by car + 1,748 by tour bus = 11,389 visitors
Max. Transit demand = [(((11,389 x 80%) + 1,080 by shuttle) x 13%) -390] = 935 rides/hr
Route Requirements = 935/263 = 4 light rail vehicles
Vehicle Headway = 40/4 = 10 minutes
Fleet Requirements = 4 vehicles + 1 spare = **5 light rail vehicles**

<u>2010 Summer Light Rail Demand</u>
Summer Design Day = 32,715 by car + 6,750 by tour bus = 39,465 visitors
Max. Transit demand = [(((39,465 x 80%) + 4,185 by shuttle) x 13%) - 495] = 4,153 rides/hr
Route Requirements = 4,153/263 = 16 light rail vehicles (8 two-car train units)
Vehicle Headway = 40/8 = 5 minutes
Fleet Requirements = 16 vehicles + 4 spares = **20 light rail vehicles**

<u>2010 Shoulder Light Rail Demand</u>
Shoulder Design Day =22,901 by car + 4,725 by tour bus = 27,626 visitors
Max. Transit demand = [(((27,626 x 80%) + 2,930 by shuttle) x 13%) - 390] = 2,864 rides/hr
Route Requirements = 2,864/263 = 12 light rail vehicles (6 two-car trains)
Vehicle Headway = 40/6 = 6.7 minutes
Fleet Requirements = 12 vehicles + 3 spares = **15 light rail vehicles**

<u>2010 Winter Light Rail Demand</u>
Winter Design Day = 11,199 by car + 2,311 by tour bus = 13,510 visitors
Max. Transit demand = [(((13,510 x 80%) + 1,433 by shuttle) x 13%) -390] = 1,201 rides/hr
Route Requirements = 1,201/263 = 5 light rail vehicles
Vehicle Headway = 40/5 = 8 minutes
Fleet Requirements = 5 vehicles + 2 spares = **7 light rail vehicles**

<u>Local Light Rail Service</u>
The local light rail service will consist of light rail vehicles traveling on the single track loop around the Village. These vehicles will stop at all three in-Park stations (Mather, Business Center, and Maswik). This route is 5.9 miles long. The average travel speeds for the local route are estimated to be 45 mph between the Center Road junction and Mather, 20 mph between Mather and Maswik, and 30 mph between Maswik and the Center Road junction. The estimated travel time of this route is 24 minutes.

Two light rail vehicles will travel as single cars on this route year-round in order to produce desirable headways of 12 minutes. Each light rail vehicle will be capable of moving 438 riders per hour around this route. The two cars on this route produce a transit supply of 875 rides per hour.

This route will serve visitors wishing to go from the Village to Mather Point or the Business Center area. The local operation will enable these visitors to accomplish this without having to travel back to Tusayan first. The number of day visitors that will use this bus route is believed to be relatively small. This route will be used by guests staying at the Yavapai Lodge, the campground, and RV park. These overnight accommodations represent about 800 guest units serving approximately 2,640 overnight guests during the summer months.

Although the number of guests staying in the campground, RV park, and the Yavapai Lodge will remain constant over time, the number of other visitors that are anticipated to use this local rail service to access the Business Center area or Mather Point is anticipated to increase with time. It is estimated that during the peak hour of the day during the summer the overnight guests staying at the facilities in the vicinity of the Business Center will generate a ridership demand of 343 rides/hr (based on a 13% peak hour factor). It was estimated that the overnight guests would generate 240 rides/hr (70% of summer) for the shoulder season and 86 rides/hr (25% of summer) for the winter season. In addition to the overnight guest demand, it is estimated that an additional demand equal to 10% of the Main-Line light rail demand will want to use the local light rail service. The estimated demand for the local light rail service is summarized below:

2000 Summer = 343 + 338 = 681 rides/hr
2000 Shoulder = 240 + 232 = 472 rides/hr
2000 Winter = 86 + 94 = 180 rides/hr
2010 Summer = 343 + 416 = 759 rides/hr
2010 Shoulder = 240 + 286 = 526 rides/hr
2010 Winter = 86 + 120 = 206 rides/hr

Table 1 summarizes the light rail requirements for each season for the years 2000 and 2010.

TABLE 1: Light Rail System Requirements

Year/Season	Main-Line Demand	Light Rail Vehicles Required Main-Line + Local + Spares	Main-line Headway
2000 Summer	3,376 Rides/hr.	14 + 2 + 3 = 19	5.7 minutes
2000 Shoulder	2,319 Rides/hr.	10 + 2 + 2 = 14	8 minutes
2000 Winter	935 Rides/hr.	4 + 2 + 1 = 8	10 minutes
2010 Summer	4,153 Rides/hr.	16 + 2 + 4 = 22	5 minutes
2010 Shoulder	2,864 Rides/hr.	12 + 2 + 3 = 17	6.7 minutes
2010 Winter	1,201 Rides/hr.	5 + 2 + 2 = 9	8 minutes

3.2 Light Rail System Personnel Requirements

The personnel requirements have been estimated based on a rate of 3 employees per active light rail vehicle in operation during peak periods (with a minimum of 12 employees). This estimate covers drivers, mechanics, and administrative personnel. The personnel estimates presented in Table 2 are based on the seasonal requirements in the years 2000 and 2010.

TABLE 2: Light Rail Personnel Requirements

Year/Season	Maximum Active Trains	Personnel Required
2000 Summer	16	48
2000 Shoulder	12	36
2000 Winter	6	18
2010 Summer	18	54
2010 Shoulder	14	42
2010 Winter	7	21

3.3 Light Rail System Capital Cost

The full-build (year 2010) light rail system capital cost was estimated to be $74.3M in 1997 dollars. A subsystem breakdown of this cost is provided in Table 3.

Recent light rail system costs were reviewed from FTA aggregate data as well as specific detailed cost data from L.A. LRT Blue Line, St. Louis LRT and San Francisco BART (RRT) projects. The high level of detail in this cost data allowed both bottom-up and top-down cost estimating approaches to be used. Data was adjusted for grade (at-grade), time (1997) and location. Costs were adjusted for location using the Engineering News Record’s cost index for 22 U.S. cities, including Los Angeles, St. Louis and San Francisco. For some items an additional bottom-up approach using the 1997 RS Means Heavy Construction Cost Data was employed.

TABLE 3: Light Rail System - Capital Cost Summary

Subsystem	Unit	Quantity	Unit Cost	Total Cost
DMU Vehicles	vehicles	22	$1,350,000	$29,700,000
Sub Grade & Track	dual-lane miles	7.83	$1,860,000	$14,563,800
Excavation	cubic yards	198,922	$8.32	$1,655,031
Embankment	cubic yards	210,309	$7.48	$1,573,111
Train Control	dual-lane miles	1.96	$1,960,000	$3,841,600
Stations	stations	4	$815,000	$3,260,000
Maintenance Facility	vehicles	22	$220,000	$4,840,000

Grade Separation at Center Road	---	---	---	$776,390
Grade Separation at Maintenance Road	---	---	---	$990,134
Pavement Removal and Replacement	square feet	108,270	$6.60	$714,582
Engineering / Proj. Mgmt.	percent	20%	---	$12,382,930
Total Costs				**$74,297,580**

It is unclear whose jurisdiction this project would fall under: the Federal Transit Administration (FTA), the Federal Railroad Administration (FRA), or possibly a State of Arizona body. Hazards analysis, quality control, quality assurance, schedule adherence, interface coordination and third-party oversight are all mechanisms which can provide the Park Service the proper level of comfort required to undertake this project. The level of detail to which these items can be taken can vary widely. These items are accounted for in the engineering and project management component of the cost estimate.

<u>Light Rail - Rolling Stock</u>
A total of 22 vehicles is specified for the year 2010 with 18 operating in the peak period and four spares. This spare ratio is considered adequate. Recent light rail vehicle costs were reviewed and adjusted for time, location and power source. The ABB/ADtranz RegioShuttle and the Bombardier Target add the potential for direct vehicle supplier competition which will keep the vehicle cost down. Assuming supplier competition, a recommended budgetary cost for DMU rail vehicles is $1.35 million per vehicle or $29.7M for the entire fleet.

<u>Light Rail Track, Switches and Train Control</u>
The light rail system in this alternative consists of the equivalent of approximately 7.83 miles of dual lane track. Ballast and sub ballast quantities were estimated for a fully loaded RegioSprinter. Other components included clear&grub, grading, embankment, underdrain, service road aisle and ballasted track procurement and installation. Given the quantities determined above, sub-grade and track has a unit cost of $1,860,000 per dual-lane mile for a total cost of $14.56M. The unit cost was estimated from both a top-down method and a bottom-up method. The top-down method incorporated total trackwork costs from FTA data (average and low), L.A. Blue Line and St. Louis LRT projects. The bottom-up method used 1997 Means Construction costs for 90 and 115 pound Relay Rail, ties, ballast, sub ballast, installation (crew) and alignment.

Components within excavation include hauling of materials, drilling and blasting, backfill and grading. Components within embankment include hauling of materials, backfill and grading. From the quantities provided, it was estimated the alignment would have approximately 199,000 cubic yards of excavation and 210,000 cubic yards of embankment. Excavation and embankment had unit costs of $8.32 and $7.48 per cubic yard respectively. Total excavation costs were $1.65M and total embankment costs were $1.57M. Unit costs were estimated from both a top-down method and a bottom-up method. The top-down method incorporated total trackwork costs from FTA data (average and low), L.A. Blue Line and St. Louis LRT projects. The bottom-up method used 1997 Means cost data.

It was assumed that train control or signalization would be implemented at the stations, along the steepest grade (3.5 and 4.0 percent) trackwork, crossovers, turnouts and road crossings. This resulted in approximately 25 percent or 1.96 dual-lane miles of the alignment having signalization. The alignment has four stations which require signalization. The signal system and its associated cost can range from simple vehicle detection systems for grade crossing protection to fully automated systems that require little or no train operator actions. For this alignment it is assumed that a fixed block-type train control system using wayside signal lights would be used with provisions for interlocking. Train control had a unit cost of $1.96 million per dual-lane mile which was estimated from both a top-down method and a bottom-up method. The total train control cost was $3.84M.

Roadway/Light Rail Grade-Separated Crossings
Two grade-separated crossings will be required. One crossing will be with Center Road, where the light rail will pass under the road in the existing drainage channel. The other crossing will be where the light rail will pass under the maintenance road that leads to the maintenance area. In both cases the roadway will need to be elevated and new concrete bridge spans installed. The cost estimates are shown below:

Crossing #1: Center Road & Light Rail
Approach Fill Req'd: 9,500 cubic meters (@ $9.00 per c.m.)= $85,000
Roadway Removal Req'd: 2,160 square meters (@ $6.00 per sq. m.)= $12,960
New Roadway Req'd: 29,527 square feet (@ $6.00 per sq. ft.)= $177,162
Total Bridge Cost: $400,000 (@ $80 per sq. ft.)
Subtotal Const. = $675,122
15% Contingency = $101,268
TOTAL COST = $776,390

Crossing #2: Maintenance Access Road & Light Rail
Approach Fill Req'd: 22,350 cubic meters (@ $9.00 per c.m.)= $201,150
Roadway Removal Req'd: 2,952 square meters (@ $6.00 per sq. m.)= $17,712
New Roadway Req'd: 40,354 square feet (@ $6.00 per sq. ft.)= $242,124
Total Bridge Cost: $400,000 (@ $80 per sq. ft.)
Subtotal Const. = $860,986
15% Contingency = $129,148
TOTAL COST = $990,134

Pavement Removal and Replacement
The light rail alignment in this alternative is concurrent with the Park road system for a portion of the route between Mather Point and the Village. A cost estimate is provided for the road work required to install the light rail tracks in the roadway. The cost estimate is based on the number of square feet of pavement removal and replacement. It was estimated that only one lane of the existing roadway would have to be removed and replaced in order to incorporate the tracks into the road. A total of approximately 108,000 square feet of pavement will have to be removed and replaced. A unit cost of $6.60 per square foot was considered appropriate for this work. The total cost of this work element is estimated to be approximately $714,000.

Light Rail Stations
The alignment has four stations (Tusayan, Mather Point, Business Center, and Maswik), all of which would be at-grade stations. The Tusayan station will be a terminating (end-of-line) station and could be designed with loading platforms on both sides of each track without the need to have any pedestrians cross the tracks. The Mather Point, Business Center and Maswik Stations will be in-line stations. Each of these stations would be equipped with a rail siding so that there will be two sets of tracks going through each station. This feature is necessary for system failure management. These sidings and their switching will allow the system to continue to operate on portions of the single-track loop when one

section of the loop is closed due to a disabled vehicle or track maintenance. These stations should be designed with loading platforms on both sides of each track. Because these are in-line stations, with through train traffic, the visitors will be required to cross the tracks to access some of the loading platforms. An at-grade pedestrian crossing of the tracks will be required in the design of these stations. Recent light rail at-grade station costs were reviewed and adjusted for time, location and assumed number of platforms per station. The resulting cost of a typical side-center-side platform at-grade light rail station is $815,000 for a total station cost of $3.26M. It is assumed the Park Service would pay for all station costs.

Light Rail Maintenance Facility
The maintenance facility cost was estimated using unit costs from recently constructed light rail system maintenance facilities, adjusted for time and location. Adjusted light rail maintenance facility costs were found to be approximately $220,000 per vehicle. The total cost of the facility was estimated to be $4.84M.

Light Rail Engineering/Project Management
Typically on FTA funded light rail transit projects, these are 25 to 30 percent of the total construction costs. These projects fall under the jurisdiction of the FTA, whose regulations are relatively extensive. With it unclear whose jurisdiction this project would fall under, it is recommended that an engineering and project management estimate of 20 percent of the total construction costs be used for a total cost of $12.38M. This reduced percentage assumes less onerous regulations and compliance than on FTA work.

3.4 Light Rail Operation and Maintenance Costs
For the year 2000, total annual operation and maintenance costs were estimated to be approximately $5.32M. From an operations analysis, an annual total of 54,874 vehicle hours were calculated. A cost of $96.90 per vehicle revenue hour was used. FTA data for light rail operating costs per vehicle revenue hour has a low of $36.90 and an average of $153.73.

For the year 2010, total operations and maintenance costs were estimated to be $6.95M. From the operations analysis, an annual total of 63,145 vehicle hours were determined. A cost of $110.00 per vehicle revenue hour was used for the 2010 O&M estimate.

3.5 Light Rail - Cost per Visitor
The cost per visitor for the light rail system is identified in Table 4 below:

TABLE 4: Light Rail Cost Per Visitor

	Year 2000	**Year 2010**
Annual Capital Cost*	$8,680,186	$8,680,186
Annual O & M Cost	$5,317,252	$6,945,950
Total Annual Cost	$13,997,438	$15,626,136
Visitation	5,182,384	6,865,000
Cost per Visitor	**$2.70**	**$2.28**

*$74,297,580 x .11683 =$8,680,186/yr based on 8% for 15 yrs

4. Bus System Requirements

4.1 Bus System Operation

A fleet of buses will provide for the visitor transportation needs in those areas of the village that are not served directly by the light rail system. The bus fleet will likely consist of 50 passenger LNG buses and 25 passenger battery powered buses. The battery buses are planned for use on the route serving Yavapai Observation Point, while the LNG buses are planned for all of the other routes included in this alternative. All of the buses in the fleet will be designed to have a low floor (14 inches or less) with wide doors opening on the right side of the vehicle.

The bus system will operate seven days a week year-round. Bus service will be available between the hours of 6 AM and 10 PM during the summer, 7AM and 9 PM during the shoulder season, and 7 AM and 8 PM during the winter. Vehicle headways will vary depending on the route and season. The headways will be 20 minutes or less. A separate on-demand dial-a-ride taxi service will be available for a fee from the concessionaire during the night after the bus service has ended.

In addition to the bus service that is common to all alternatives (West Rim, Yaki Point) this alternative includes additional buses operating on three other fixed routes. These routes include Mather - Yavapai Museum, Business Center Loop, and Village Loop. These routes are described below:

Mather-Yavapai Museum Route - 3.0 mile round trip route (25 MPH avg. speed)
2 stops (2 min/stop) - Mather Point and Yavapai Museum
12 minute round trip travel time.

Demand Assumption:

The bus service will be used to regulate the visitor flow to the museum. Anticipated demand will be greatly influenced by the specific loading location at Mather, the frequency of the buses and the amount of marketing performed. It is likely that this demand could increase significantly if the route were highly advertised. Actual demand is unknown. For the purposes of this analysis it is assumed that demand for this bus service will be 10% of the light rail demand. It is assumed that 25 passenger, battery powered buses will be used on this route. The service requirements of this route are shown in Table 5.

TABLE 5: Mather - Yavapai Museum Bus Route

Year/Season	Estimated Demand	Buses Required	Headway	Transit Supply
2000 Summer	338 rides/hr	3 - 25 passenger buses	4 minutes	375 rides/hr
2000 Shoulder	232 rides/hr	2 - 25 passenger buses	6 minutes	250 rides/hr
2000 Winter	94 rides/hr	1 - 25 passenger bus	12 minutes	125 rides/hr
2010 Summer	415 rides/hr	4 - 25 passenger buses	3 minutes	500 rides/hr
2010 Shoulder	286 rides/hr	3 - 25 passenger buses	4 minutes	375 rides/hr
2010 Winter	120 rides/hr	1 - 25 passenger bus	12 minutes	125 rides/hr

Business Center Loop Bus Route - 2.2 mile round trip route (20 MPH avg. speed)
5 stops (1 min/stop)- Business Center, Yavapai Lodge, Yavapai East, Campground, and RV Park
12 minute round trip travel time

Demand Assumption:

This route will primarily serve overnight guests wishing to circulate between the developments in the vicinity of the Business Center. The number of day visitors that will use this bus route is believed to be relatively small. This route also serves as the only bus access to the Yavapai Lodge, the campground, and RV park. These overnight accommodations represent about 800 guest units serving approximately 2,640 overnight guests during the summer months. Many of these overnight guests will ride this bus to access their lodge or camping area. The overnight guests will likely use this bus to circulate throughout the business area.

The number of guests staying in the campground, RV park, and the Yavapai Lodge will remain constant over time. It is estimated that during the peak hour of the day during the summer the overnight guests staying at the facilities in the vicinity of the Business Center will generate a ridership demand of 343 rides/hr (based on a 13% peak hour factor). It was estimated that the overnight guests would generate 240 rides/hr (70% of summer) for the shoulder season and 86 rides/hr (25% of summer) for the winter season. Table 7 shows the service requirements of this route.

TABLE 7: Business Center Loop Bus Route

Year/Season	Estimated Demand	Buses Required	Headway	Transit Supply
2000 Summer	343 rides/hr	2 - 50 passenger buses	6 minutes	500 rides/hr
2000 Shoulder	240 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr
2000 Winter	86 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr
2010 Summer	343 rides/hr	2 - 50 passenger buses	6 minutes	500 rides/hr
2010 Shoulder	240 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr
2010 Winter	86 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr

Village Loop Bus Route - 1.75 mile route (20 MPH avg. speed)
6 stops - (1 min/stop) El Tovar, Bright Angle, West Rim Interchange, Maswik Lodge, Maswik T.C., and Heritage Campus
12 minute round trip travel time
Summer 2010 demand = 25% of rail demand = 1,038 rides/hr

Demand Assumptions:

This bus route will circulate throughout the Village with a stop at the Light Rail station. The current bus service on the Village Loop provides the equivalent of about 500 rides per hour (over the length of the entire route). Without their vehicles the visitor is expected to rely more on this route for moving about the Village. It is estimated that the demand for this bus service will be 20% of the light rail demand. For the purposes of this analysis it is assumed that 25 passenger battery powered buses would be used on the Village Loop Bus Route. The service requirements of the Village Loop Bus Route are shown in Table 8.

Note that during the winter season it may be desirable to use two 25 passenger battery powered buses for the Village Loop instead of the single 50 passenger vehicle that is used on this route during the rest of the year. The use of two of the smaller buses on this route during the winter months would produce a more desirable headway of 6 minutes versus the 12 minute headway shown in Table 8.

TABLE 8: Village Loop Bus Route

Year/Season	Estimated Demand	Buses Required	Headway	Transit Supply
2000 Summer	675 rides/hr	3 - 50 passenger bus	4 minutes	750 rides/hr
2000 Shoulder	464 rides/hr	3 - 50 passenger bus	4 minutes	500 rides/hr
2000 Winter	187 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr
2010 Summer	830 rides/hr	4 - 50 passenger bus	3 minutes	875 rides/hr
2010 Shoulder	573 rides/hr	3 - 50 passenger bus	4 minutes	625 rides/hr
2010 Winter	240 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr

For the purposes of this analysis it was assumed that the existing bus fleet would be used to provide service on the West Rim and Yaki Point routes (routes common to all alternatives). The routes specific to this alternative would be served with new buses. Table 9 lists the total number of buses required for each season in the years 2000 and 2010. The fleet requirements shown in Table 9 do not include any of the existing NPS buses.

TABLE 9: Total Bus Fleet Requirements

Year/Season	50 Passenger LNG Buses (Active + Spares)	25 Passenger Battery Buses (Active +Spares)	Total Fleet (Active plus Spares)
2000 Summer	5 + 2 = 7	3 + 1 = 4	8 + 3 = 11
2000 Shoulder	4 + 1 = 5	2 + 1 = 3	6 + 2 = 8
2000 Winter	2 + 1 = 3	1 + 1 = 2	3 + 2 = 5
2010 Summer	6 + 2 = 8	4 + 1 = 5	10 + 3 = 13
2010 Shoulder	4 + 1 = 5	3 +1 = 4	7 + 2 = 9
2010 Winter	2 + 1 = 3	1 + 1 = 2	3 + 2 = 5

4.2 Bus System Personnel Requirements

The personnel requirements have been estimated at a rate of 3.5 employees per active bus in the fleet (not counting spare buses). This estimate covers drivers, mechanics, and administrative personnel. Table 10 shows the seasonal personnel requirements for the bus system for the years 2000 and 2010.

TABLE 10: Bus Personnel Requirements

Year/Season	Maximum Active Fleet	Personnel Required
2000 Summer	8	28
2000 Shoulder	6	21
2000 Winter	3	11
2010 Summer	10	35
2010 Shoulder	7	25
2010 Winter	3	11

4.3 Bus System Capital Cost

The capital costs for the bus service includes the rolling stock, a maintenance facility and a vehicle storage facility.

Bus - Rolling Stock

The cost of the rolling stock is based on 50 passenger, 40 foot-long, low-floor, LNG-powered buses and 25 passenger battery-powered buses. The cost for the rolling stock is based on the fleet requirements for the peak summer ridership demand for the years 2000 and 2010. A unit price of $300,000 was estimated for each LNG bus and $275,000 for each battery powered bus that will be used on this system. The fleet requirements for the year 2000 are 7 LNG buses and 4 battery buses. The initial purchase cost for the fleet will be an estimated $3.2M. The ultimate fleet requirements for the 2010 demands are a total fleet size of 8 LNG buses and 5 battery buses that will cost approximately $3.775M.

To properly assess the cost of using the fleet, it is necessary to calculate an annual depreciation value for the fleet. This was accomplished using an average service life of 15 years for the vehicles and an 8% rate of interest. This yields an annual use fee for the year 2000 fleet of about $374,000 ($3,200,000 x 0.11683 = $373,856/year). In the year 2010 the full fleet requirements will increase the annual fee to about $441,000 per year ($3,775,000 x 0.11683 = $441,033/year).

Bus Maintenance Facility

The bus maintenance facility should be sized at the rate of one service bay per every 10 buses with a minimum of two bays. Each bay is estimated to be 2,000 sf. Additional space is required for tools, equipment, and parts. This space is estimated based on the number of service bays at the rate of 1,000 sf per bay. The administrative area for the transit operation will be included in the maintenance facility. Maintenance facilities have been sized for the 2010 summer design values. An estimated unit price for the maintenance facility is $150 per square foot. (13 buses -- 2 bays x 3,000 sf = 6,000 sf building x $150/sf = $900,000)

In addition to the maintenance building, the bus fleet will also require a maintenance yard area for temporary vehicle storage and vehicle fueling. This area is anticipated to be paved and sized at the rate of 1,000 sf per bus. A cost of $200,000 per acre is estimated for the maintenance yard. (13 buses x 1,000 sf = 0.3 acres x $200,000/acre = $60,000)

The fleet will require a bus barn for night storage. The bus barn includes an unheated sheet metal building on a concrete slab floor with overhead lighting and electrical service only. The bus barn is sized based on 650 square feet per bus. A fleet of 13 buses will require a 8,450 square foot bus barn. Bus barns are estimated to cost approximately $20 per square foot. (13 buses x 650 sf = 8,450 sf x $20/sf = $169,000)

Bus System Capital Cost Summary
The following data summarizes the capital costs associated with the transit operation. The cost estimates shown in Table 11 are based on the 2010 design year needs and include all infrastructure costs except the cost of the rolling stock. The estimated $1.129M capital cost investment will be annualized using a 20 year pay back period and 8% interest. This yields an annualized cost of about $115,000 per year ($1,129,000 x 0.10185 = $114,989/year).

TABLE 11: Bus - Capital Cost Estimate*

Item	Units	Unit Price	Estimated Cost
Maintenance Building	6,000sf	$150/sf	$900,000
Maintenance Yard	0.3 acres	$200,000/acre	$ 60,000
Bus Barn	8,450sf	$20/sf	$169,000
TOTAL			**$1,129,000**

* Does not include rolling stock.

4.4 Bus System Operation and Maintenance Costs

The operation cost includes the labor, fuel, parts and maintenance. The transit operators contacted as part of the research indicated a range of operational costs. The lowest rate was $2.50 per mile and the highest rate was $4.50 per mile. For the purposes of this analysis an O&M cost of $3.50 per mile was considered appropriate for the year 2000 and a rate of $4.00 per mile for the year 2010. The increase in the O&M rate is to account for inflation. For the purposes of this calculation the daily miles driven was estimated using 90% of the full service hour miles driven. The annual operating cost for the system in the year 2000 is estimated to be about $1.1M and in the year 2010 about $1.5M. A breakdown of the O&M costs is shown in Table 12.

TABLE 12: Bus - O&M Costs

Year and Season	Miles Driven Per Day	O&M Cost Per Day	O&M Cost Per Season
2000 Summer	1,343	$4,701	$427,791
2000 Shoulder	847	$2,965	$539,630
2000 Winter	407	$1,425	$129,675
2000 Total			**$1,097,096/Yr**
2010 Summer	1,685	$6,740	$613,340
2010 Shoulder	1,036	$4,144	$754,208
2010 Winter	407	$1,628	$148,148
2010 Total			**$1,515,696/Yr**

4.5 Bus System- Cost Per Visitor

A cost per visitor figure was developed using the 2010 data which includes the annual capital costs (20 year pay back with 8% interest) plus the O&M costs. This would be the fee that would have to be charged to each Park visitor to pay for the service. It is assumed that the cost of the transit system would by paid for by all visitors to the Park (North and South Rims, year-round) and not only the transit riders. The cost per visitor data is presented in Table 13.

TABLE 13: Bus System - Cost Per Visitor

	Year 2000	Year 2010
Annual O&M Cost	$1,097,096	$1,515,696
Annual Capital Cost*	$114,989	$114,989
Annual Fee for use of Rolling Stock	$373,856	$441,033
Total Annual Cost	**$1,585,941**	**$2,071,718**
Projected Annual Visitation	5,182,384	6,865,000
Cost Per Visitor	**$0.31**	**$0.30**

* Does not include cost for using rolling stock.

4.6 Bus Fleet Replacement Costs

The Park Service may desire to plan for the next generation of buses by assessing a fleet replacement fee. It is assumed that the next fleet will be needed in about 15 years and will cost considerably more than the present fleet due to inflation. Using a 3% annual inflation factor the next fleet is estimated to cost approximately $5.89M [($300,000 x 1.56 x 8 buses = $3,744,000) +($275,000 x 1.56 x 5 = $2,145,000)=$5,889,000]. Using an 8% interest factor the annual fleet replacement fee would be about $688,000 ($5,889,000 x 0.11683 = $688,012). If the annual fleet replacement fee were added to the per visitor cost it would yield a year 2000 cost of **$0.44** per visitor and a year 2010 cost of **$0.43** per visitor.

5. System Advantages and Disadvantages

<u>Advantages</u>

* System provides rail access to several areas within the Park
* Simple system to operate
* System provides village access with a minimal amount of vegetated area disturbed between Mather Point and the Village
* Requires a small bus fleet to complement the rail service
* The light rail system can be easily access from the GCRR tracks and therefore the light rail vehicles and other rail equipment can be delivered by rail and transported from the site for heavy maintenance
* Local light rail service on the single track loop provides circulation and access to most areas of the Village

Disadvantages

*The light rail alignment passes through the Historic Village

* Noise, air quality and visual impacts from the rail vehicles will occur in the vicinity of the Business Center and in the Village

*The stations at Mather Point, the Business Center, and Maswik will be in-line stations with pedestrian traffic crossing the tracks in these stations to get to the loading platforms

*The right rail vehicles will pass through areas of the Village that will have large numbers of pedestrian traffic

* The Single track loop in the Village has less failure management options than other alternatives that have double track

APPENDIX D
Design Parameters - Preferred Alternative
Visitor Transit System
Grand Canyon National Park, Arizona

This document is intended to provide the members of the Grand Canyon GMP Implementation Team with updated information about the design parameters related to the development of the preferred alternative for a visitor transit system within the Park. The preferred alternative includes a light rail passenger service operating between a parking area to be located outside of the Park near the north end of Tusayan and two locations within the Park. These destinations are: a new Visitor Orientation Center at Mather Point, and the Maswik Transportation Center. A fleet of buses operating on several fixed routes will be used to provide visitor circulation within the Village. Both the light rail and the bus service will operate year-round.

All visitors to the Village would be required to park at the lot in Tusayan and ride the light rail system to access Mather Point, the Village, and the West Rim. Overnight guest vehicles will be allowed on specific Park roads for the sole purpose of accessing their designated lodge parking area or campground. Tour buses will not be allowed access to Mather Point or the Village. Tour bus passengers will have to change over to the light rail system in order to visit Mather Point and all points to the west.

1. Visitor and Vehicle Projections

1.1 Design Day Calculations

<u>Assumptions used in Design Day calculations:</u>

1994 Total Visitation = 4,172,814	1994 South Rim Visitation = 3,751,014
2000 Total Visitation = 5,182,384	2000 South Rim Visitation = 4,722,259
2010 Total Visitation = 6,865,000	2010 South Rim Visitation = 6,341,000

<u>Modal Split</u>

For the purposes of this analysis the mode splits for the year 2000 are estimated to be 75% by car, 8.4% by shuttle bus, 13.6% by tour bus, and 3% by train. In the 2010 design year the modal splits are 72.7% by car, 9.3% by shuttle bus, 15% by tour bus and 3% by GCRR train.

<u>YEAR 2000 - South Rim</u>

<u>Summer Design Day 2000 = 37,554 visitors</u>

75% private veh. = 28,166 vis. by private veh./ 3.3 PPV = 8,535 veh. (8,180 cars & 355 RV’s)
8.4% shuttle bus = 3,155 vis. by shuttle bus/ 31 PPV = 102 shuttle buses
13.6% tour bus = 5,107 vis. by tour bus/ 31 PPV = 165 tour buses
3% train = 1,127 vis. by train

<u>Winter Design Day 2000 = 12,855 visitors</u>

75% private veh. = 9,641 vis. by private veh./ 2.6 PPV = 3,708 veh. (3,542 cars & 166 RV’s)
8.4% shuttle bus = 1,080 vis. by shuttle bus/ 31 PPV = 35 shuttle buses
13.6% tour bus = 1,748 vis. by tour bus/ 31 PPV = 56 tour buses
3% train = 386 vis. by train

YEAR 2010 - South Rim

Summer Design Day 2010 = 45,000 visitors
72.7% private veh. = 32,715 vis. by private veh./ 3.3 PPV = 9,914 veh. (9,502 cars & 412 RV's)
9.3% shuttle bus = 4,185 vis. by shuttle bus/ 31 PPV = 135 shuttle buses
15% tour bus = 6,750 vis. by tour bus/ 31 PPV = 218 tour buses
3% train = 1,350 vis. by train

Winter Design Day 2010 = 15,404 visitors
72.7% private veh. = 11,199 vis. by private veh./ 2.6 PPV = 4,307 veh. (4,130 cars & 177 RV's)
9.3% shuttle bus = 1,433 vis. by shuttle bus/ 31 PPV = 46 shuttle buses
15% tour bus = 2,311 vis. by tour bus/ 31 PPV = 75 tour buses
3% train = 462 vis. by train

2. Parking Requirements

Tusayan Parking Area

The parking area at Tusayan should be sized to accommodate the peak summer demand in 2010. The vehicle projections presented in the first section of this memo, an 80/20 split between the Village and the East Rim, and a 40% accumulation rate were used to estimate the parking requirements at the Tusayan site. It is estimated that the parking area should be sized to handle approximately 3,041 cars, 132 RV's, and 70 buses. Using 300 sf per car and 1,000 sf per bus and RV, the parking area would have a 25.6 acre paved surface.

3. Light Rail System Requirements

3.1 Light Rail System Operation

The light rail portion of the transit system will operate between Tusayan, Mather Point and the Maswik Transportation Center. The roadbed for the light rail system will be located in a dedicated right-of-way. A double track roadbed will be used for the majority of the system. The main line of the light rail system will be located to the west of and parallel to the South Entrance Road between Tusayan and Mather Point. From Mather the light rail service will continue on to the Maswik area of the Village by back tracking south to Center Road where the main line between Tusayan and Mather will intersect the Village spur line. The Village spur line will be located to the south of and generally parallel to Center Road. The light rail track will connect to the existing Grand Canyon Railroad (GCRR) tracks in the Maswik area of the Village.

The tracks used for the light rail service will cross the Park road system at two locations. The main line will cross the access road to the existing "Dry Dump" maintenance area and Center Road. A bridge structure will be used at both of these locations to enable road traffic to cross over the main line tracks of the light rail system.

The light rail system will operate seven days a week year-round. During the summer season (June - August) light rail service with maximum vehicle headways of about five minutes will be available between the hours of 6 AM and 10 PM. Between the hours of 10 PM and 6 AM light rail service will be provided by a single vehicle operating on a one hour frequency. A separate on-demand dial-a-ride taxi service will also be available for a fee from the concessionaire between 10 PM and 6 AM.

During the shoulder seasons (September-November and March-May) the light rail service will operate between the hours of 7 AM and 9 PM. Maximum vehicle headways of 10 minutes will be maintained during the day the same as during the summer season. Evening light rail service between the hours of 9 PM and 7 AM will be similar to the summer night operation with hourly service.

During the winter season (December- February) the light rail service will be available between the hours of 7 AM and 8 PM. Maximum vehicle headways of 15 minutes will be maintained during the day. Evening light rail service between the hours of 8 PM and 7 AM will be similar to the summer night operation with hourly service.

The round-trip route is approximately 16 miles in length and the average operating speed of the vehicles is 45 MPH on the Main Line and 30 MPH on the Village Spur Line. Stops for loading and unloading will only occur at the three terminals and are estimated to take three minutes per stop. The estimated round-trip travel time is estimated to be 35 minutes including the stops. During peak periods during the summer and shoulder seasons the light rail vehicles will be connected together to form two-car trains. Each light rail vehicle will carry 175 passengers (seated plus standing) and provide a total of 300 rides per vehicle per hour (600 per two-car train).

The transit system is sized to accommodate the peak hourly load. A peak hour factor of 13% of the daily demand was used. The 80% distribution factor was used the same as in the parking calculation. A total of 495 overnight guests (150 vehicles x 3.3 PPV) were subtracted from the peak hour summer transit demand. A total of 390 overnight guests (150 vehicles x 2.6 PPV) were subtracted from the peak hour transit demand during the shoulder and winter seasons.

Note that the shoulder season demand was estimated to be 70% of the summer demand value.

<u>2000 Summer Light Rail Demand</u>
Summer Design Day = 28,166 by car + 5,107 by tour bus = 33,273 visitors
Max. Transit demand = [(((33,273 x 80%) + 3,155 by shuttle bus) x 13%) - 495] = 3,376 rides/hr
Route Requirements = 3,376/300 = 12 light rail vehicles (6 two-car train units)
Vehicle Headway = 35/6 = 5.8 minutes
Fleet Requirements = 12 vehicles + 3 spares = **15 light rail vehicles**

<u>2000 Shoulder Light Rail Demand</u>
Shoulder Design Day = 19,716 by car+ 3,575 by tour bus = 23,291 visitors
Max. Transit demand = [(((23,291 x 80%) + 2,209 by shuttle bus) x 13%) - 390] = 2,319 rides/hr
Route Requirements = 2,319/300 = 8 light rail vehicles (4 two-car trains)
Vehicle Headway = 35/4 = 8.75 minutes
Fleet Requirements = 8 vehicles + 2 spares = **10 light rail vehicles**

<u>2000 Winter Light Rail Demand</u>
Winter Design Day = 9,641 by car + 1,748 by tour bus = 11,389 visitors
Max. Transit demand = [(((11,389 x 80%) + 1,080 by shuttle) x 13%) -390] = 935 rides/hr
Route Requirements = 935/300 = 4 light rail vehicles
Vehicle Headway = 35/4 = 8.75 minutes
Fleet Requirements = 4 vehicles + 2 spares = **6 light rail vehicles**

2010 Summer Light Rail Demand
Summer Design Day = 32,715 by car + 6,750 by tour bus = 39,465 visitors
Max. Transit demand = [(((39,465 x 80%) + 4,185 by shuttle) x 13%) - 495] = 4,153 rides/hr
Route Requirements = 4,153/300 = 14 light rail vehicles (7 two-car train units)
Vehicle Headway = 35/7 = 5 minutes
Fleet Requirements = 14 vehicles + 3 spares = **17 light rail vehicles**

2010 Shoulder Light Rail Demand
Shoulder Design Day =22,901 by car + 4,725 by tour bus = 27,626 visitors
Max. Transit demand = [(((27,626 x 80%) + 2,930 by shuttle) x 13%) - 390] = 2,864 rides/hr
Route Requirements = 2,864/300 = 10 light rail vehicles (5 two-car trains)
Vehicle Headway = 35/5 = 7 minutes
Fleet Requirements = 10 vehicles + 2 spares = **12 light rail vehicles**

2010 Winter Light Rail Demand
Winter Design Day = 11,199 by car + 2,311 by tour bus = 13,510 visitors
Max. Transit demand = [(((13,510 x 80%) + 1,433 by shuttle) x 13%) -390] = 1,201 rides/hr
Route Requirements = 1,201/300 = 4 light rail vehicles
Vehicle Headway = 35/4 = 8.75 minutes
Fleet Requirements = 4 vehicles + 2 spares = **6 light rail vehicles**

Table 1 summarizes the light rail system requirements for each season for the years 2000 and 2010.

TABLE 1: Light Rail System Requirements

Year/Season	Demand	Light Rail Vehicles Required (Route requirements plus spares)	Headway
2000 Summer	3,376 Rides/hr.	12 + 3 = 15	5.8 minutes
2000 Shoulder	2,319 Rides/hr.	8 + 2 = 10	8.75 minutes
2000 Winter	935 Rides/hr.	4 + 2 = 6	8.75 minutes
2010 Summer	4,153 Rides/hr.	14 + 3 = 17	5 minutes
2010 Shoulder	2,864 Rides/hr.	10 + 2 = 12	7 minutes
2010 Winter	1,201 Rides/hr.	4 + 2 = 6	8.75 minutes

3.2 Light Rail System Personnel Requirements

The personnel requirements have been estimated based on a rate of 3 employees per active light rail vehicle in operation during peak periods. This estimate covers drivers, mechanics, and administrative personnel. The personnel estimates presented in Table 2 are based on the seasonal requirements in the years 2000 and 2010.

TABLE 2: Light Rail Personnel Requirements

Year/Season	Maximum Active Trains	Personnel Required
2000 Summer	12	36
2000 Shoulder	8	24
2000 Winter	4	12
2010 Summer	14	42
2010 Shoulder	10	30
2010 Winter	4	12

3.3 Light Rail System Capital Cost

The full-build (year 2010) light rail system capital cost was estimated to be $67.3 million in 1997 dollars. A subsystem breakdown of this cost is provided in Table 3.

Recent light rail system costs were reviewed from FTA aggregate data as well as specific detailed cost data from L.A. LRT Blue Line, St. Louis LRT and San Francisco BART (RRT) projects. The high level of detail in this cost data allowed both bottom-up and top-down cost estimating approaches to be used. Data was adjusted for grade (at-grade), time (1997) and location. Costs were adjusted for location using the Engineering News Record's cost index for 22 U.S. cities, including Los Angeles, St. Louis and San Francisco. For some items an additional bottom-up approach using the 1997 RS Means Heavy Construction Cost Data was employed.
A summary of the capital costs for the light rail system is shown in Table 3.

TABLE 3: Light Rail System - Capital Cost

Subsystem	Unit	Quantity	Unit Cost	Total Cost
DMU Vehicles	vehicles	17	$1,350,000	$22,950,000
Sub Grade & Track	dual-lane miles	8.95	$1,860,000	$16,647,000
Excavation	cubic yards	260,448	$8.32	$2,166,750
Embankment	cubic yards	275,358	$7.48	$2,060,800
Train Control	dual-lane miles	2.2	$1,960,000	$4,312,000
Stations	stations	3	$815,000	$2,445,000
Maintenance Facility	vehicles	17	$220,000	$3,740,000
Grade Separation at Center Road	---	---	---	$776,390
Grade Separation at Maintenance Road	---	---	---	$990,134
Engineering / Proj. Mgmt.	percent	20%	---	$11,217,615
Total Costs				**$67,305,689**

It is unclear whose jurisdiction this project would fall under: the Federal Transit Administration (FTA), the Federal Railroad Administration (FRA), or possibly a State of Arizona body. Hazards analysis, quality control, quality assurance, schedule adherence, interface coordination and third-party oversight are all mechanisms which can provide the Park Service the proper level of comfort required to undertake this project. The level of detail to which these items can be taken can vary widely. These items are accounted for in the engineering and project management component of the cost estimate.

<u>Light Rail - Rolling Stock</u>
A total of seventeen vehicles is specified for the year 2010 with fourteen operating in the peak period and three spares. This spare ratio is considered adequate. Recent light rail vehicle costs were reviewed and adjusted for time, location and power source. The ABB/ADtranz RegioShuttle and the Bombardier Target add the potential for direct vehicle supplier competition which will keep the vehicle cost down. Assuming supplier competition, a recommended budgetary cost for DMU rail vehicles is $1.35 million per vehicle or $22.95 million for the entire fleet.

<u>Light Rail Track, Switches and Train Control</u>
The preferred alignment system consists of approximately 8.95 miles of dual lane track. Ballast and sub ballast quantities were estimated for a fully loaded RegioSprinter. Other components included clear&grub, grading, embankment, underdrain, service road aisle and ballasted track procurement and installation. Given the quantities determined above, sub-grade and track has a unit cost of $1,860,000 per dual-lane mile for a total cost of $16.6 million. The unit cost was estimated from both a top-down method and a bottom-up method. The top-down method incorporated total trackwork costs from FTA data (average and low), L.A. Blue Line and St. Louis LRT projects. The bottom-up method used 1997 Means Construction costs for 90 and 115 pound Relay Rail, ties, ballast, sub ballast, installation (crew) and alignment.

Components within excavation include hauling of materials, drilling and blasting, backfill and grading. Components within embankment include hauling of materials, backfill and grading. From the quantities provided, it was estimated the preferred alignment would have approximately 260,000 cubic yards of excavation and 275,000 cubic yards of embankment. Excavation and embankment had unit costs of $8.32 and $7.48 per cubic yard respectively. Total excavation costs were $2.2 million and total embankment costs were $2.1 million. Unit costs were estimated from both a top-down method and a bottom-up method. The top-down method incorporated total trackwork costs from FTA data (average and low), L.A. Blue Line and St. Louis LRT projects. The bottom-up method used 1997 Means cost data.

It was assumed that train control or signalization would be implemented at the three stations, along the steepest grade (3.5 and 4.0 percent) trackwork, crossovers, turnouts and road crossings. This resulted in approximately 25 percent or 2.2 dual-lane miles of the alignment having signalization. The preferred alignment system has three terminating stations. Terminating or end-of-line stations require a greater degree of signalization due to the train's turnback operations. The signal system and its associated cost can range from simple vehicle detection systems for grade crossing protection to fully automated systems that require little or no train operator actions. For the Grand Canyon alignment it is assumed that a fixed block-type train control system using wayside signal lights would be used with provisions for interlocking. Train control had a unit cost of $1.96 million per dual-lane mile which was estimated from both a top-down method and a bottom-up method. The total train control cost was $4.3 million.

Roadway/Light Rail Grade-Separated Crossings
Two grade-separated crossings will be required. One crossing will be with Center Road, where the light rail will pass under the road in the existing drainage channel. The other crossing will be where the light rail will pass under the maintenance road that leads to the maintenance area. In both cases the roadway will need to be elevated and new concrete bridge spans installed. The cost estimates are shown below:

Crossing #1: Center Road & Light Rail
Approach Fill Req'd: 9,500 cubic meters (@ $9.00 per c.m.)= $85,000.00
Roadway Removal Req'd: 2,160 square meters (@ $6.00 per sq. m.)= $12,960.00
New Roadway Req'd: 29,527 square feet (@ $6.00 per sq. ft.)= $177,162.00
Total Bridge Cost: $400,000.00 (@ 80.00 per sq. ft.)
Subtotal Const. = $675,122
15% Contingency = $101,268
TOTAL COST = $776,390

Crossing #2: Maintenance Access Road & Light Rail
Approach Fill Req'd: 22,350 cubic meters (@ $9.00 per c.m.)= $201,150.00
Roadway Removal Req'd: 2,952 square meters (@ $6.00 per sq. m.)= $17,712.00
New Roadway Req'd: 40,354 square feet (@ $6.00 per sq. ft.)= $242,124.00
Total Bridge Cost: $400,000.00 (@ $80.00 per sq. ft.)
Subtotal Const. = $860,986
15% Contingency = $129,148
TOTAL COST = $990,134

Light Rail Stations
The preferred alignment has three stations (Tusayan, Mather Point and near the Maswick Transportation Center), all of which would be at-grade, terminating (end-of-line) stations. Recent light rail at-grade station costs were reviewed and adjusted for time, location and assumed number of platforms per station. The resulting cost of typical side-center-side platform at-grade light rail station is $815,000 for a total station cost of $2.45 million. It is assumed the Park Service would pay for all station costs.

Light Rail Maintenance Facility
The cost of the maintenance facility cost was estimated based on the cost of other recently constructed light rail system maintenance facilities, adjusted for time and location. Adjusted light rail maintenance facility costs were found to be approximately $220,000 per vehicle. The total cost of the facility was estimated to be $3.74 million.

Light Rail Engineering/Project Management
Typically on FTA funded light rail transit projects, these are 25 to 30 percent of the total construction costs. These projects fall under the jurisdiction of the FTA, whose regulations are relatively extensive. With it is unclear whose jurisdiction this project would fall under, an engineering and project management estimate of 20 percent of the total construction costs was used for a total cost of $11.2 million.

3.4 Light Rail System Operation and Maintenance Costs
For the year 2000, total operations and maintenance costs were estimated to be approximately $3.7 million. From an operations analysis, a total of 38,329 hours were calculated. Resulting costs were $96.90 per vehicle revenue hour. FTA data for light rail operating costs per vehicle revenue hour has a low of $36.90 and an average of $153.73.

For the year 2010, total operations and maintenance costs were estimated to be $5 million. From the operations analysis, a total of 45,536 hours were determined. The cost per vehicle revenue hour used for the 2010 cost estimate was increased to $110.00 per vehicle hour to acount for infation.

3.5 Light Rail Cost Per Visitor

The cost per visitor for the light rail system is identified in Table 4 below:

TABLE 4: Light Rail Cost Per Visitor

	Year 2000	Year 2010
Annual Capital Cost*	$7,863,324	$7,863,324
Annual O & M Cost	$3,714,000	$5,008,960
Total Annual Cost	$11,577,324	$12,872,284
Visitation	5,182,384	6,865,000
Cost per Visitor	**$2.23**	**$1.88**

*$67,305,689 x .11683 =$7,863,324/yr based on 8% for 15 yrs

4. Bus System Requirements

4.1 Bus System Operation

A fleet of buses will provide for the visitor transportation needs in those areas of the village that are not served directly by the light rail system. The bus fleet will likely consist of 50 passenger LNG buses and 25 passenger battery powered buses. The electric buses are planned for use on the route serving Yavapai Observation Point, while the LNG buses are planned for all of the other routes included in the Preferred Alternative. All of the buses in the fleet will be designed to have a low floor (14 inches or less) with wide doors opening on the right side of the vehicle.

The bus system will operate seven days a week year-round. Bus service will be available between the hours of 6 AM and 10 PM during the summer, 7AM and 9 PM during the shoulder season, and 7 AM and 8 PM during the winter. Vehicle headways will vary depending on the route and season. In most cases the headways will always be 20 minutes or less. A separate on-demand dial-a-ride taxi service will be available for a fee from the concessionaire during the night after the bus service has ended.

In addition to the bus service that is common to all alternatives (West Rim, Yaki Point) the preferred alternative includes additional buses operating on four other fixed routes. These routes include Mather - Yavapai Museum, Mather - Business Center, Village - Business Center, and Village Loop. These routes are described below:

Mather-Yavapai Museum Route - 3.0 mile round trip route (25 MPH avg. speed)
2 stops (2 min/stop) - Mather Point and Yavapai Museum
12 minute round trip travel time.

Demand Assumption:

The bus service will be used to regulate the visitor flow to the museum. Anticipated demand will be greatly influenced by the specific loading location at Mather, the frequency of the buses and the amount of marketing performed. It is likely that this demand could increase significantly if the route were highly advertised. Actual demand is unknown. For the purposes of this analysis it is assumed that demand for this bus service will be 10% of the light rail demand. It is assumed that 25 passenger, battery powered buses will be used on this route. The service requirements of this route are shown in Table 5.

TABLE 5: Mather - Yavapai Museum Bus Route

Year/Season	Estimated Demand	Buses Required	Headway	Transit Supply
2000 Summer	338 rides/hr	3 - 25 passenger buses	4 minutes	375 rides/hr
2000 Shoulder	232 rides/hr	2 - 25 passenger buses	6 minutes	250 rides/hr
2000 Winter	94 rides/hr	1 - 25 passenger bus	12 minutes	125 rides/hr
2010 Summer	415 rides/hr	4 - 25 passenger buses	3 minutes	500 rides/hr
2010 Shoulder	286 rides/hr	3 - 25 passenger buses	4 minutes	375 rides/hr
2010 Winter	120 rides/hr	1 - 25 passenger bus	12 minutes	125 rides/hr

Mather-Business Center Route - 2.7 mile round trip route (20 MPH avg. speed)
6 stops (1 min/stop)- Mather Point and Business Center, Yavapai Lodge, Yavapai East, Campground, and RV Park
15 minute round trip travel time

Demand Assumption:

This route will serve visitors wishing to go directly from Mather Point to the Business Center for grocery shopping, banking and postal needs. The number of day visitors that will use this bus route is believed to be relatively small. This route also serves as the only bus access to the Yavapai Lodge, the campground, and RV park. These overnight accommodations represent about 800 guest units serving approximately 2,640 overnight guests during the summer months. Many of these overnight guests will ride this bus to access their lodge or camping area. The overnight guests will likely use this bus to circulate throughout the business area and will transfer to the Village - Business Center Bus Route to access the other areas of the Village.

Although the number of guests staying in the campground, RV park, and the Yavapai Lodge will remain constant over time, the number of other visitors that use this bus service to access the Business Center area or Mather Point is anticipated to increase with time. It is estimated that during the peak hour of the day during the summer the overnight guests staying at the facilities in the vicinity of the Business Center will generate a ridership demand of 343 rides/hr (based on a 13% peak hour factor). It was estimated that the overnight guests would generate 240 rides/hr (70% of summer) for the shoulder season and 86 rides/hr (25% of summer) for the winter season. In addition to the overnight guest demand, it is estimated that an additional demand equal to 10% of the light rail demand will desire to ride this bus service.

Table 6 shows the service requirements of this route. Note that the Winter 2010 demand slightly exceeds the supply allocated.

TABLE 6: Mather - Business Center Bus Route

Year/Season	Estimated Demand	Buses Required	Headway	Transit Supply
2000 Summer	343 +338 =681 rides/hr	4 - 50 passenger buses	3.75 minutes	800 rides/hr
2000 Shoulder	240 + 232 = 472 rides/hr	3 -50 passenger buses	5 minutes	600 rides/hr
2000 Winter	86 + 94 =180 rides/hr	1 - 50 passenger bus	15 minutes	200 rides/hr
2010 Summer	343 + 416 = 759 rides/hr	4 - 50 passenger buses	3.75 minutes	800 rides/hr
2010 Shoulder	240 + 286 = 526 rides/hr	3 - 50 passenger buses	5 minutes	600 rides/hr
2010 Winter	86 + 120 =206 rides/hr	1 - 50 passenger bus	15 minutes	200 rides/hr

Village-Business Center Route - 3.0 mile round trip route (25 MPH avg. speed)
2 stops (2 min/stop)- Maswik T.C. and Business Center
12 minute round trip travel time

Demand Assumption:

The ridership demand for the Village - Business Route is assumed to be the same as the Mather - Business Route. The service requirements for this route are shown in Table 7.

TABLE 7: Village - Business Center Bus Route

Year/Season	Estimated Demand	Buses Required	Headway	Transit Supply
2000 Summer	343 +338 =681 rides/hr	3 - 50 passenger buses	4 minutes	750 rides/hr
2000 Shoulder	240 +232 = 472 rides/hr	2 - 50 passenger buses	6 minutes	500 rides/hr
2000 Winter	86 + 94 =180 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr
2010 Summer	343 + 416 = 759 rides/hr	3 - 50 passenger buses	4 minutes	750 rides/hr*
2010 Shoulder	240 +286 = 526 rides/hr	3 - 50 passenger bus	4 minutes	750 rides/hr
2010 Winter	86 + 120 =206 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr

* The estimated demand slightly exceeds the supply.

Village Loop Bus Route - 1.75 mile route (20 MPH avg. speed)
6 stops - (1 min/stop) El Tovar, Bright Angle, West Rim Interchange, Maswik Lodge, Maswik T.C., and Heritage Campus
12 minute round trip travel time
Summer 2010 demand = 25% of rail demand = 1,038 rides/hr

Demand Assumptions:

This route will circulate throughout the Village with a stop at the Light Rail station. The current bus service on the Village Loop provides the equivalent of about 500 rides per hour (over the length of the entire route). Without their vehicles the visitor is expected to rely more on this route for moving about the Village. It is estimated that the demand for this bus service will be 20% of the light rail demand. For the purposes of this analysis it is assumed that 25 passenger battery powered buses would be used to provide the Village Loop bus service. The service requirements of the Village Loop Bus Route are shown in Table 8.

Note that during the winter season it may be desirable to use two 25 passenger battery powered buses for the Village Loop instead of the single 50 passenger vehicle that is used on this route during the rest of the year. The use of two of the smaller buses on this route during the winter months would produce a more desirable headway of 6 minutes versus the 12 minute headway shown in Table 8.

TABLE 8: Village Loop Bus Route

Year/Season	Estimated Demand	Buses Required	Headway	Transit Supply
2000 Summer	675 rides/hr	3 - 50 passenger bus	4 minutes	750 rides/hr
2000 Shoulder	464 rides/hr	2- 50 passenger bus	6 minutes	500 rides/hr
2000 Winter	187 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr
2010 Summer	830 rides/hr	4 - 50 passenger bus	3 minutes	875 rides/hr
2010 Shoulder	573 rides/hr	3 - 50 passenger bus	4 minutes	625 rides/hr
2010 Winter	240 rides/hr	1 - 50 passenger bus	12 minutes	250 rides/hr

For the purposes of this analysis it was assumed that the existing bus fleet would be used to provide service on the West Rim and Yaki Point routes (routes common to all alternatives). The routes specific to the preferred Alternative would be served with new buses. Table 9 lists the total number of buses required for each season in the years 2000 and 2010. The fleet requirements shown in Table 9 do not include any of the existing NPS buses.

TABLE 9: Total Bus Fleet Requirements

Year/Season	50 Passenger LNG Buses (Active + Spares)	25 Passenger Battery Buses (Active +Spares)	Total Fleet (Active plus Spares)
2000 Summer	10 + 3 = 13	3 + 1 = 4	13 + 4 = 17
2000 Shoulder	8 + 2 = 10	2 + 1 = 3	10 + 3 = 13
2000 Winter	3 + 1 = 4	1 + 1 = 2	4 + 2 = 6
2010 Summer	11 + 3 = 14	4 + 1 = 5	15 + 4 = 19
2010 Shoulder	9 + 3 = 12	3 +1 = 4	12 + 4 = 16
2010 Winter	3 + 1 = 4	1 + 1 = 2	4 + 2 = 6

4.2. Bus System Personnel Requirements.
The personnel requirements have been estimated at a rate of 3.5 employees per active bus in the fleet (not counting spare buses). This estimate covers drivers, mechanics, and administrative personnel. Table 10 shows the seasonal personnel requirements for the bus system for the years 2000 and 2010.

TABLE 10: Bus Personnel Requirements

Year/Season	Maximum Active Fleet	Personnel Required
2000 Summer	13	46
2000 Shoulder	10	35
2000 Winter	4	14
2010 Summer	15	53
2010 Shoulder	12	42
2010 Winter	4	14

4.3 Bus System Capital Cost
The capital costs for the bus service includes the rolling stock, a maintenance facility and a vehicle storage facility.

Bus - Rolling Stock
The cost of the rolling stock is based on 50 passenger, 40 foot-long, low-floor, LNG-powered buses and 25-passenger electric buses. The cost for the rolling stock is based on the fleet requirements for the peak summer ridership demand for the years 2000 and 2010. A unit price of $300,000 was estimated for each LNG bus and 275,000 for each battery powered bus that will be used on this system. The fleet requirements for the year 2000 are 13 LNG buses and 4 battery buses. The initial purchase cost for the fleet will be an estimated $5.0M. The ultimate fleet requirements for the 2010 demands will require a total fleet size of 14 LNG buses and 5 battery buses that will cost approximately $5.575M.

To properly assess the cost of using the fleet, it is necessary to calculate an annual depreciation value for the fleet. This was accomplished using an average service life of 15 years for the vehicles and an 8% rate of interest. This yields an annual use fee for the fleet of about $584,000 for the fleet needed in the year 2000 ($5,000,000 x 0.11683 = $584,150/year). In the year 2010 the full fleet requirements will increase the annual fee to about $651,000 per year ($5,575,000 x 0.11683 = $651,327/year).

Bus Maintenance Facility
The bus maintenance facility should be sized at the rate of one service bay per every 10 buses with a minimum of two bays. Each bay is estimated to be 2,000 sf. Additional space is required for tools, equipment, and parts. This space is estimated based on the number of service bays at the rate of 1,000 sf per bay. The administrative area for the transit operation will be included in the Maintenance facility. Maintenance facilities have been sized for the 2010 summer design values. An estimated unit price for the maintenance facility is $150 per square foot. (19 buses -- 2 bays x 3,000 sf = 6,000 sf building x $150/sf = $900,000)

In addition to the maintenance building, the bus fleet will also require a maintenance yard area for temporary vehicle storage and vehicle fueling. This area is anticipated to be paved and sized at the rate of 1,000 sf per bus. A cost of $200,000 per acre is estimated for the maintenance yard. (19 buses x 1,000 sf = 0.44 acres x $200,000/acre = $88,000)

The fleet will require a bus barn for night storage. The bus barn includes an unheated sheet metal building on a concrete slab floor with overhead lighting and electrical service only. The bus barn is sized based on 650 square feet per bus. A fleet of 16 buses will require a 10,400 square foot bus barn. Bus barns are estimated to cost approximately $20 per square foot. (19 buses x 650 sf = 12,350 sf x $20/sf = $247,000)

Bus System Capital Cost Summary
The following data summarizes the capital costs associated with the transit operation. The cost estimates shown in Table 11 are based on the 2010 design year needs and include all infrastructure costs except the cost of the rolling stock. The estimated $1.182M capital cost investment will be annualized using a 20 year pay back period and 8% interest. This yields an annualized cost of about $120,000 per year ($1,235,000 x 0.10185 = $125,785/year).

TABLE 11: Bus - Capital Cost Estimate*

Item	Units	Unit Price	Estimated Cost
Maintenance Building	6,000sf	$150/sf	$900,000
Maintenance Yard	0.44 acres	$200,000/acre	$88,000
Bus Barn	12,350sf	$20/sf	$247,000
TOTAL			**$1,235,000**

*Does not include rolling stock.

4.4. Bus System Operation and Maintenance Costs
The operation cost includes the labor, fuel, parts and maintenance. The transit operators contacted as part of the research indicated a range of operational costs. The lowest rate was $2.50 per mile and the highest rate was $4.50 per mile. For the purposes of this analysis an O&M cost of $3.50 per mile was considered appropriate for the year 2000 and a rate of $4.00 per mile for the year 2010. The increase in the O&M rate is to account for inflation. For the purposes of this calculation the daily miles driven was estimated using 90% of the full service hour miles driven.

The annual operating cost for the system in the year 2000 is estimated to be about $1.8M and in the year 2010 about $2.4M. A breakdown of the O&M costs is shown in Table 12.

TABLE 12 : Bus - O&M Costs

Year and Season	Miles Driven Per Day	O&M Cost Per Day	O&M Cost Per Season
2000 Summer	2,296	$8,036	$731,276
2000 Shoulder	1,385	$4,848	$882,245
2000 Winter	580	$2,030	$184,730
2000 Total			**$1,798,251/Yr**
2010 Summer	2,638	$10,552	$960,232
2010 Shoulder	1,873	$7,492	$1,225,952
2010 Winter	580	$2,320	$211,120
2010 Total			**$2,397,304/Yr**

4.5 Bus - Cost Per Visitor
A cost per visitor figure was developed using the 2010 data which includes the annual capital costs (20 year pay back with 8% interest) plus the O&M costs. This would be the fee that would have to be charged to each Park visitor to pay for the service. It is assumed that the cost of the transit system would by paid for by all visitors to the Park (North and South Rims, year-round) and not only the transit riders. The cost per visitor data is presented in Table 13.

TABLE 13: Bus System Cost Per Visitor

	Year 2000	Year 2010
Annual O&M Cost	$1,798,251	$2,397,304
Annual Capital Cost*	$125,785	$125,785
Annual Fee for use of Rolling Stock	$584,327	$651,327
Total Annual Cost	**$2,508,363**	**$3,174,416**
Projected Annual Visitation	5,182,384	6,865,000
Cost Per Visitor	**$0.48**	**$0.46**

* Does not include cost for using rolling stock.

4.6 Bus Fleet Replacement Costs
The Park Service may desire to plan for the next generation of buses by assessing a fleet replacement fee. It is assumed that the next fleet will be needed in about 15 years and will cost considerably more than the present fleet due to inflation. Using a 3% annual inflation factor the next fleet is estimated to cost approximately $8.7M [($300,000 x 1.56 x 14 buses = $6,552,000) +($275,000 x 1.56 x 5 = $2,145,000)=$8,697,000]. Using an 8% interest factor the annual fleet replacement fee would be about $1,016,000 ($8,697,000 x 0.11683 = $1,016,071). If the annual fleet replacement fee were added to the

per visitor cost it would yield a year 2000 cost of **$0.67** per visitor and a year 2010 cost of **$0.61** per visitor.

5. System Advantages and Disadvantages

Advantages

* the alignment has a minimal number of at-grade crossings
* all major road crossings are grade separated
* the light rail operation will be free from delays created by visitor traffic
* the route times and headways are dependable and will be predictable
* double track design throughout provides good failure management options
* all of the stations can be stub end stations with multiple platforms for greatest efficiency
* all stations can be designed as stub-end stations so visitors never need to cross the active light rail tracks to get to or from the loading platform
* most of the route can be constructed without conflicting with any of the other modes of transportation at the Park

Disadvantages

* the light rail system does not go by the Business Center area of the Village and therefore this area of the Village will have to be served by bus
* the Y alignment produces twice as many train passes of the campground area as compared to the open loop alignment
* cost of second set of tracks between Mather and Maswik
* visitors will feel like they are back-tracking when the train leaves the Mather station on its way to Maswik. This may cause some visitor confusion.

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